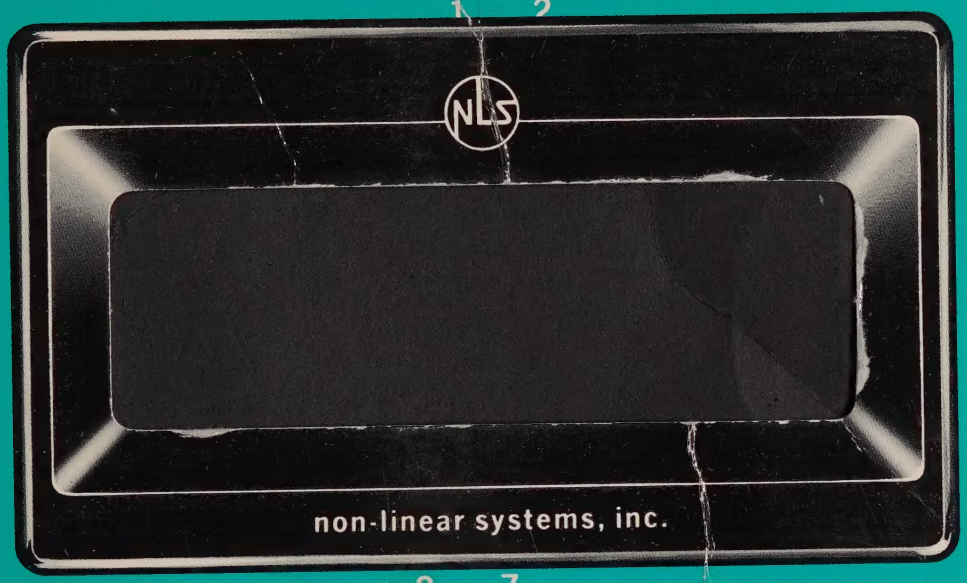
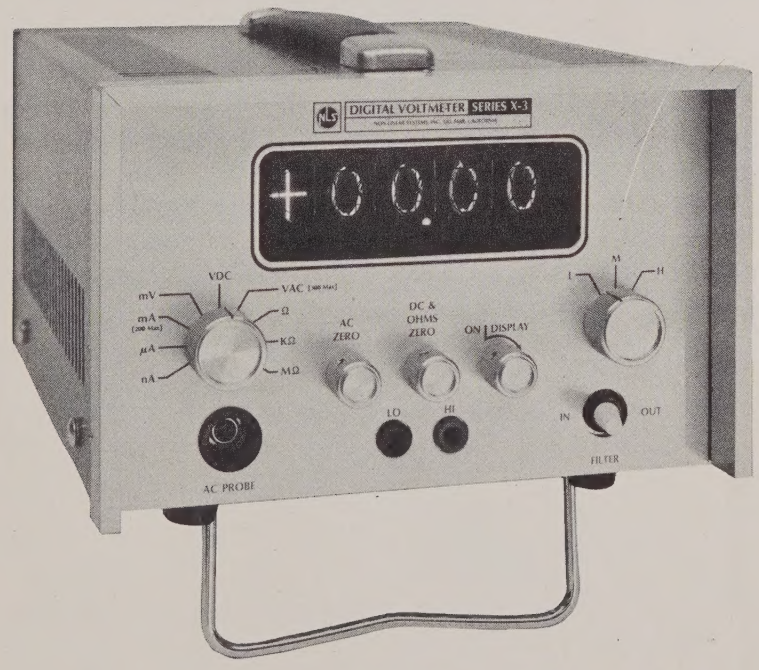



# non linear systems, inc.

DEL MAR, CALIFORNIA

Document No. 1172
Revision A
October 1968

# INSTRUCTION MANUAL
## SERIES X-3
*(MODEL A)*
## DIGITAL VOLTMETER




This Document applies to Series X-3 DVM's bearing Part Number 38-4 (S/N X-3.2000 & Subsequent).

*Originator of the Digital Voltmeter*
**non-linear systems, inc.**
DEL MAR (SAN DIEGO), CALIFORNIA

*Printed in the United States of America*

*Entire contents copyright, 1968. No part of this book may be reproduced without written permission from Non-Linear Systems, Inc., Del Mar, Calif.*

## NOTICE

AFTER UNPACKING THE INSTRUMENT AND CABLES, NOTE AND RECORD BELOW THE SERIAL NO. OF THE INSTRUMENT AND THE SERIAL NO. OF THE AC PROBE CABLE, P/N 38-50. THE INSTRUMENT SHIPPED WITH THIS INSTRUCTION MANUAL HAS BEEN CALIBRATED IN THE VAC MODE WITH THE PARTICULAR AC PROBE CABLE INCLUDED IN THE SHIPMENT. IF ANY OTHER AC PROBE CABLE IS USED WITH THIS INSTRUMENT, THE INSTRUMENT MUST FIRST BE RE-CALIBRATED TO THAT PARTICULAR AC PROBE CABLE (SEE CHAPTER III, CALIBRATION INSTRUCTIONS). READ THE ENTIRE TEXT OF THIS MANUAL BEFORE SERVICING.

SERIAL NO. OF INSTRUMENT_____

SERIAL NO. OF AC CABLE _____

# TABLE OF CONTENTS


| Chapter | Title | Page |
|---|---|---|
| I | INTRODUCTION AND SPECIFICATIONS | 1-1 |
| II | INSTALLATION AND OPERATION | 2-1 |
| | Unpacking | 2-1 |
| | Power Source | 2-1 |
| | Fusing | 2-1 |
| | Power Grounding | 2-1 |
| | Connectors | 2-2 |
| | Cables | 2-2 |
| | Controls | 2-2 |
| | Function Switch | 2-2 |
| | Range Switch | 2-4 |
| | On Display | 2-4 |
| | AC Zero | 2-4 |
| | DC & Ohms Zero | 2-4 |
| | Filter Switch | 2-4 |
| | Digital Readout | 2-4 |
| | Operation | 2-4 |
| | Zeroing the Readout | 2-4 |
| | MVDC or VDC Zero | 2-4 |
| | Current Zero | 2-5 |
| | Ohms Zero | 2-5 |
| | AC Zero | 2-5 |
| | Cable Connections | 2-5 |
| III | THEORY OF OPERATION | 3-1 |
| | Introduction | 3-1 |
| | Signal Conditioning Section | 3-1 |
| | Signal Conditioning for Millivolt DC Measurement | 3-2 |
| | Signal Conditioning for Volts DC Measurement | 3-2 |
| | Signal Conditioning for Current Measurements | 3-2 |
| | Signal Conditioning for Volts AC Mode | 3-3 |
| | Signal Conditioning for Resistance Measurements | 3-6 |
| | Digitizing Section | 3-8 |
| | Polarity Sensing | 3-10 |
| | Polarity Drivers | 3-11 |
| | Reaching a Reading | 3-12 |

## TABLE OF CONTENTS (CON'T)


| Chapter | Title | Page |
|---|---|---|
| III | THEORY OF OPERATION (Con't) | 3-1 |
| | Digital Section, General Operation | 3-12 |
| | Clock Pulse Generator | 3-14 |
| | Overload Sense Circuitry | 3-14 |
| IV | CALIBRATION AND MAINTENANCE | 4-1 |
| | Calibration | 4-1 |
| | Equipment Required | 4-1 |
| | Initial Preparation | 4-1 |
| | Procedure | 4-1 |
| | Maintenance | 4-4 |
| | Access to Components | 4-4 |
| | Troubleshooting | 4-4 |
| | Equipment Required | 4-4 |
| | Initial Preparation | 4-4 |
| | Procedure | 4-9 |
| V | PARTS LIST | 5-1 |
| | DVM Final Assembly | 5-1 |
| | DVM Assenbly, Main Board and Power Supply | 5-2 |
| | Power Supply Board Assembly | 5-2 |
| | R/O and Counter Assembly, 38-115 | 5-4 |
| | Attenuator Assembly, 38-98 | 5-6 |
| | Amplifier and Logic Assembly, 38-113 | 5-8 |
| | D/A Converter and Reference Assembly, 38-107 | 5-10 |
| | APPENDIX | A-1 |


## LIST OF TABLES


| Table | Title | Page |
|---|---|---|
| I | Measurement Capabilities | 2-3 |

## LIST OF ILLUSTRATIONS


| Figure | Title | Page |
|---|---|---|
| 2-1 | Power Plug Pin Coding | 2-1 |
| 2-2 | Front View | 2-2 |
| 2-3 | Rear View | 2-2 |
| 3-1 | Signal Conditioning for Millivolts DC Measurement | 3-1 |
| 3-2 | Signal Conditioning for Volts DC Measurement | 3-2 |
| 3-3 | Signal Conditioning for Milliampere Measurement | 3-3 |
| 3-4 | Signal Conditioning for Microampere Measurement | 3-4 |
| 3-5 | Signal Conditioning for Nanoampere Measurement | 3-4 |
| 3-6 | Input Probe and Attenuator Board Signal | 3-5 |
| 3-7 | Simplified Diagram, Resistance Measurement | 3-6 |
| 3-8 | Signal Conditioning for Resistance Measurement | 3-7 |
| 3-9 | Constant Current Source | 3-8 |
| 3-10 | Block Diagram, Digitizing Section | 3-9 |
| 3-11 | Polarity Sensing Circuit | 3-10 |
| 3-12 | Polarity Driver Circuitry | 3-11 |
| 3-13 | Type SN7400N Quadruple 2-Input Positive Nand Gate | 3-12 |
| 3-14 | Type SN7490N Decade Counter | 3-13 |
| 3-15 | Type SN7441AN BCD-Decimal Decoder/Driver | 3-14 |
| 3-16 | Up-Down Digital Logic | 3-15/3-16 |
| 3-17 | Clock Pulse Circuitry | 3-17/3-18 |
| 3-18 | Overload Sense Circuitry | 3-17/3-18 |
| 3-19 | DVM Schematic Diagram | 3-19/3-20 |
| 4-1 | Amplifier and Logic Assembly Adjustments and Test Points | 4-2 |
| 4-2 | DVM Top View | 4-3 |
| 4-3 | MVDC and VDC Calibration | 4-5 |
| 4-4 | Current Calibration | 4-6 |
| 4-5 | Ohms Calibration | 4-7 |
| 4-6 | VAC Calibration | 4-8 |
| 4-7 | Clock Pulses | 4-10 |
| 4-8 | Decade "One Bit" | 4-11 |
| 4-9 | Decade "Two Bit" | 4-11 |
| 5-1 | DVM Final Assembly | 5-1 |
| 5-2 | DVM Assembly, Main Board and Power Supply | 5-2 |
| 5-3 | Power Supply Board Assembly | 5-2 |
| 5-4 | R/O and Counter Assembly. | 5-4 |
| 5-5 | Attenuator Assembly. | 5-6 |
| 5-6 | Amplifier and Logic Assembly | 5-8 |
| 5-7 | D/A Converter and Reference Assembly | 5-10 |

## LIST OF SCHEMATIC DIAGRAMS


| Drawing No. | Title | Page |
|---|---|---|
| 38-110 | Main Board and Power Supply Assembly | 5-3 |
| 38-115 | R/O and Counter Assembly | 5-5 |
| 38-98 | Attenuator Assembly | 5-7 |
| 38-113 | Amplifier and Logic Assembly | 5-9 |
| 38-107 | D/A Converter and Reference Assembly | 5-11/5-12 |

# CHAPTER I

# INTRODUCTION AND SPECIFICATIONS

The Series X-3 Multipurpose Digital Voltmeter is a light weight, portable, three-digit instrument with automatic polarity and with provisions for 1999 counts to full scale in most ranges and functions (See specifications for exceptions).

The measuring capabilities of the Series X-3 include eight current ranges, (nine with external shunt), nine ohms ranges, three millivolt (DC) ranges, three VDC ranges and three VAC ranges. An additional DC range (10 KV) may be obtained by use of a high voltage probe.

Another unique feature of the X-3 is an analog output proportional to the signal being measured. Connectors for this purpose are located on the rear of the instrument.

The Series X-3's circuitry is all solid state and its speed and accuracies are considerably higher than any other instrument in its class.

## SPECIFICATIONS

### DC VOLTAGE

| RANGE | OVER-RANGE | RESOLUTION | ACCURACY* |
|---|---|---|---|
| 10 mV | 19.99 mV | 10 μV | 0.2% Rdg. + 0.5% F.S. |
| 100 mV | 199.9 mV | 100 μV | 0.1% Rdg. + 0.1% F.S. |
| 1000 mV | 1999. mV | 1 mV | |
| 10 V | 19.99 V | 10 mV | |
| 100 V | 199.9 V | 100 mV | |
| 1000 V | 0999. V (Maximum) | 1 V | 0.1% Rdg. + 0.2% F.S. |
| 10000 V (With Probe | 19.99 KV | 10 V | 3% Rdg. + 0.1% F.S. |
| 100,000V (With Probe) | 30.0 KV (Maximum) | 100 V | 3% Rdg. + 1.0% F.S. |

### DC CURRENT

| | | | |
|---|---|---|---|
| 10 nA | 19.99 nA | 10 pA | 20% Rdg. + 0.5% F.S. |
| 100 nA | 199.9 nA | 100 pA | 5% Rdg. + 0.5% F.S. |
| 1000 nA | 1999. nA | 1 nA | 0.5% Rdg. + 0.5% F.S. |
| 10 μA | 19.99 μA | 10 nA | 0.2% Rdg. + 0.1% F.S. |
| 100 μA | 199.9 μA | 100 nA | 0.1% Rdg. + 0.1% F.S. |
| 1000 μA | 1999. μA | 1 μA | |
| 10 mA | 19.99 mA | 10 μA | |
| 100 mA | 199.9 mA (Maximum) | 100 μA | |

*ASA Reference Conditions Only

## SPECIFICATIONS (Con't)

### OHMS

| RANGE | OVER-RANGE | | RESOLUTION | ACCURACY |
|---|---|---|---|---|
| 10Ω | 19.99Ω | @10 mA | 10 mΩ | 0.1% Rdg. + 0.2% F.S. |
| 100Ω | 199.9Ω | @1 mA | 100 mΩ ) | |
| 1000Ω | 1999Ω | @100 μA | 1Ω ) | 0.1% Rdg. + 0.1% F.S. |
| 10 KΩ | 19.99 KΩ | @10 μA | 10Ω ) | |
| 100 KΩ | 199.9 KΩ | @1 μA | 100Ω ) | |
| 1000 KΩ | 1999 KΩ | @100 nA | 1 KΩ | 0.5% Rdg. + 0.1% F.S. |
| 10 MegΩ | 19.99 MegΩ | @100 nA | 10 KΩ | 1% Rdg. + 0.2% F.S. |
| 100 MegΩ | 199.9 MegΩ | @10 nA | 100 KΩ | 20% Rdg. + 0.2% F.S. |
| 1000 MegΩ | 1999 MegΩ | @1 nA | 1 MegΩ | Usable for relative measurements |

### AC VOLTAGE

| | | | |
|---|---|---|---|
| 10 V | 19.99 V | 10 mV | 3% F.S. (0.5V & Up)** |
| 100 V | 199.9 V | 100 mV | 3% F.S. ** |
| 1000 V(300 V Maximum) | | 1 V | 3% F.S. ** |

Frequency Response: (400 Hz Reference)

±10% - 20 Hz to 100 Hz
± 2% - 100 Hz to 100 MHz
±10% - 100 Hz to 700 MHz

POWER: 105-125 Volts, 20 Watts.

DIMENSIONS: 6" High, 8-9/16" Wide, 11-29/32" Deep.

WEIGHT: Approximately 13 lbs.

* ASA Reference Conditions Only
** @400 Hz

# CHAPTER II

# INSTALLATION AND OPERATION

## UNPACKING

The instrument is shipped in a heavy cardboard container. Cut the tape on the top of the container and open. If damage is observed, promptly notify the carrier. Immediately check the packing slip for possibility of shortages.

**CAUTION**

Do not operate the instrument before ensuring that each plug-in board is firmly in place. Failure to take this precaution may cause damage to components on the board assemblies.

## POWER SOURCE

The instrument is usually supplied for operation from 105-125 volt, 50-400 Hz, single phase power sources. However, the instrument will operate from 210-250 volt, 50-400 Hz, single phase sources if the two primaries of the power transformer are wired in series instead of in parallel (See schematic diagram 38-110). The serial number tag at the rear of the instrument indicates the correct power source if other than 105-125 volts or 50-400 Hz.

## FUSING

The instrument is protected by a 3AG 3/8 ampere fuse (F1) which is located on the rear panel. When a 210-250 volt power source is to be used (and the power transformer primary rewired as indicated above), it is recommended that a 3/16 ampere fuse be used to provide maximum protection. Two additional fuses (F1 and F3) are located on the Attenuator Assembly (38-98) and the D/A Converter and Reference Assembly (38-107) respectively. F3 on assembly 38-107 is provided to guard the ohms input circuit against any inadvertant application of voltage or current into the ohms input connector. F1 on assembly 38-98 is provided to guard against any inadvertant application of current greater than the rating of the instrument.

## POWER GROUNDING

The third pin of the power plug grounds the outer chassis of the instrument (Figure 2-1). Despite the presence of the third grounding pin, there is no real assurance that the instrument will be correctly connected since

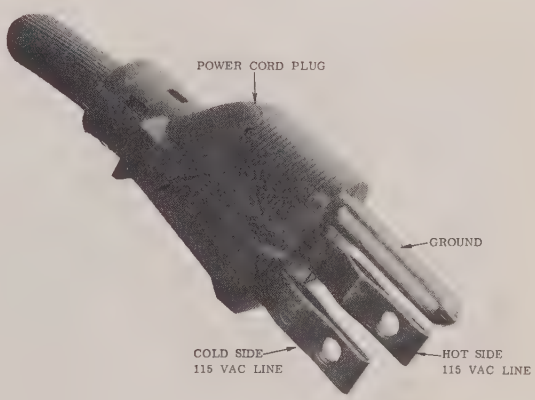



Figure 2-1. Power Plug Pin Coding

the power outlets in many installations are erroneously wired. Be certain that the power source is in agreement with the power and grounding requirements of the instrument.

## CONNECTORS (Figures 2-2 & 2-3)

Three input connectors are located on the front panel of the instrument; they are color-coded and labeled as to function:

| | |
|---|---|
| AC PROBE | Phone Jack (no color) |
| SIGNAL HI | Red |
| SIGNAL LO | Black |

Five connectors are located on the rear panel. Two provide the analog output of the instrument (1mA maximum). The red connector is signal high; the black connector is signal low. Three connectors are labeled ACCESSORY POWER SUPPLY and provide approximately 40 VAC at 200 mA.

## CABLES

Three cables are provided with each instrument; the part number, color and function of each are as follows:

| | | |
|---|---|---|
| 15004-608-3 | Black | LO |
| 15004-609 | Red | HI |
| 38-50 | Black with Silver Probe | AC Probe |

## CONTROLS (Figure 2-2)

### FUNCTION SWITCH

The function switch is a nine-position switch, located on the front panel of the instrument. The position for each measurement function is appropriately labeled (See Table I).

Figure 2-2. Front View

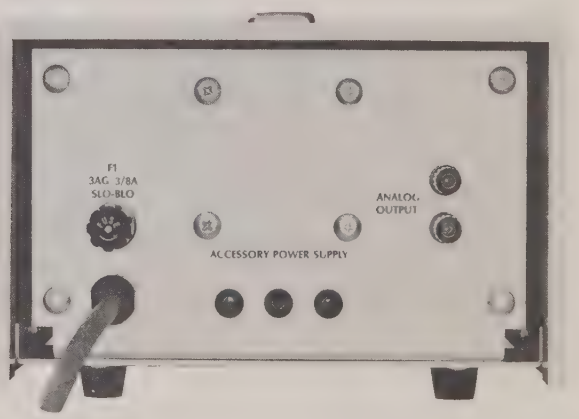



Figure 2-3. Rear View

Table I. Measurement Capabilities

| FUNCTION SWITCH POSITION | RANGE SWITCH POSITION | | |
|---|---|---|---|
| | L | M | H |
| nA | 19.99 nA RANGE → | 199.9 nA RANGE → | 1999. nA RANGE |
| μA | 19.99 μA RANGE → | 199.9 μA RANGE → | 1999. μA RANGE |
| mA | 19.99 mA RANGE → | 100 mA RANGE (200 mA Max.) | 2 AMPS Max. with External Shunt |
| MV | 19.99 mVDC RANGE → | 199.9 mVDC RANGE → | 1999. mVDC RANGE |
| VDC | 19.99 VDC RANGE → | 199.9 VDC RANGE → | 1000 VDC RANGE 1000 VDC MAX. |
| VDC | (30KV WITH PROBE) | | |
| VAC | 19.99 VAC RANGE (0.5V MIN) → | 199.9 VAC RANGE → | 1000 VAC RANGE 300 VAC MAX. |
| Ω | 10.00 Ω RANGE → | 100.0 Ω RANGE → | 1999. Ω RANGE |
| KΩ | 19.99 KΩ RANGE → | 199.9 KΩ RANGE → | 1999. KΩ RANGE |
| MEGΩ | 19.99 MEGΩ RANGE → | 199.9 MEGΩ RANGE → | 1000 MEGΩ RANGE |

NOTE: WHEN INSTRUMENT INDICATES 1999, RANGE/FUNCTION SWITCHES SHOULD BE ROTATED AS INDICATED BY ARROWS UNTIL A READING IS OBTAINED BETWEEN 0199 AND 1998. THIS WILL BE THE PROPER RANGE AND THE MOST ACCURATE READING OF WHICH THE INSTRUMENT IS CAPABLE WILL BE DISPLAYED.

RANGE SWITCH

The range switch is a three position switch, located on the front panel of the instrument. The positions for each range measurement are labeled L, M, and H (See Table I).

ON DISPLAY

The ON DISPLAY control, located on the front panel of the instrument, serves as a power switch and as a control to permit noisy input signals to be measured (turn clockwise). Maximum reading speed is obtained with this control turned counter-clockwise (up to the position that would turn the power off). Compensate for noisy signals by rotating this control clockwise as required.

AC ZERO

The AC ZERO control, located on the front panel of the instrument, is provided to zero the readout prior to taking VAC readings.

DC & OHMS ZERO

The DC & OHMS ZERO control, located on the front panel of the instrument, is provided to zero the readout prior to taking current, MVDC, VDC or ohms readings.

FILTER SWITCH

The FILTER SWITCH is a two position toggle switch and is located on the front panel of the instrument. It is labeled IN and OUT and is provided to attenuate noisy input signals. In the higher resistance ranges, the filter may be switched out to obtain faster readings.

DIGITAL READOUT

The instrument is supplied with five readout tubes; polarity (+ or -) and overload (1) display; over-range (O) or (1) display; and three 0 thru 9 digital and decimal displays (left to right respectively). The 1 display will illuminate when the input reaches full scale of the range in use.

OPERATION

1. Plug power cord into 115VAC, 50-400 Hz, single phase power source.
2. Turn ON DISPLAY control clockwise until an audible click is heard. Allow 30 minutes for instrument warm-up.
3. Place function switch in the position (as labeled) to obtain desired function to be measured (See Table I).
4. Place range switch in position to obtain desired range to be measured (Table I).

NOTE

To obtain measurements within instrument's specified accuracies, it is essential that the readout of the instrument be brought to all zeros prior to operation and prior to measurement after EACH range OR function change.

ZEROING THE READOUT

MVDC or VDC Zero

1. Place function switch in mV or VDC position.
2. Plug red and black input cables into their matching-color connectors or use a shielded input cable with standard 3/4-inch connector.
3. Connect leads of cables together and adjust DC & OHMS ZERO control until readout displays all zeros.

Current Zero

1. Place function switch in nA, μA, or mA position.
2. Plug red and black input cables into their matching-color connectors or use a shielded input cable with standard 3/4-inch connector.
3. With leads of cables open, adjust DC & OHMS ZERO control until readout displays all zeros. Because of noise pick-up, a more accurate zero may be obtained in the nA mode if the red lead is removed from the instrument.

Ohms Zero

1. Place function switch in Ω, KΩ, or MEGΩ position.
2. Plug red and black input cables into their matching-color connectors.
3. Connect leads of cables together and adjust DC & OHMS ZERO control until readout displays all zeros.

AC Zero

1. Plug VAC cable into AC PROBE connector. Allow 5 minutes for warm-up.
2. Zero the instrument in VDC mode as set forth above.
3. Place function switch in VAC position.
4. Connect leads of cable together and adjust AC ZERO control until readout displays all zeros.

CABLE CONNECTIONS

For signal measurement, connect instrument cables to signal source as shown in applicable calibration instructions (Figures 4-3 thru 4-6).

NOTE

Since the circuitry in the Series X-3 Digital Voltmeter is not connected to power ground, differential measurements above ground may be made. However, the signal to be measured, should first be analyzed to determine which terminal has the lowest impedance to ground so that the black input lead (LO) of the X-3 may be connected to it.

# CHAPTER III

# THEORY OF OPERATION

## INTRODUCTION

The Series X-3 consists of two basic sections. A Signal Conditioning Section conditions resistance, current and voltage inputs into a normalized DC analog signal. The Digitizing Section accepts a normalized analog signal from the Signal Conditioning Section and converts it into a visual digital display.

To assure ease of understanding, the Theory of Operation has been divided into the following two major paragraphs:

1. Signal Conditioning Section
2. Digitizing Section

Subdivisions within each of these major paragraphs describe the various circuits making up each section. An overall schematic diagram of the instrument is located at the end of this chapter.

## SIGNAL CONDITIONING SECTION

The Attenuator Board (p/n 39-98) converts and conditions resistance, current and voltage input signals into a linearized voltage. The linearized voltage is equal to three millivolts at the output of the buffer amplifier A1 (p/n 38-64) for each digit to be displayed in the readout. Scaling and conditioning of the many functions of the X-3 are discussed in the following paragraphs; simplified schematic diagrams are presented to augment the discussion.

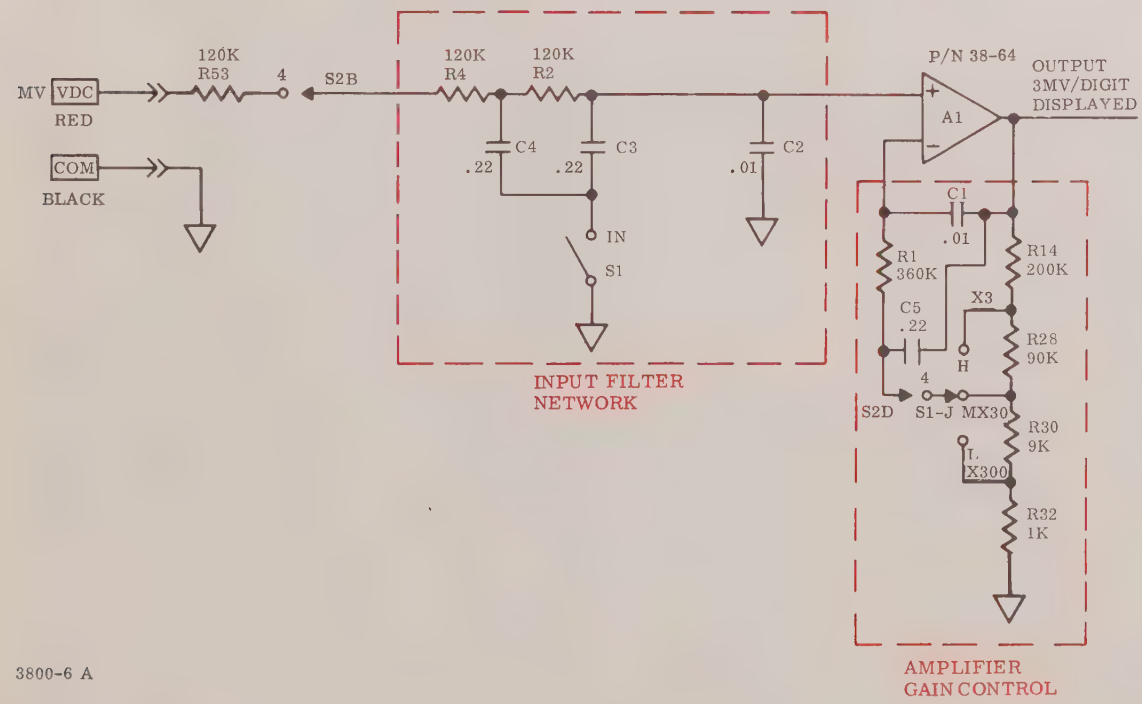



Figure 3-1. Signal Conditioning for Millivolts DC Measurement

## SIGNAL CONDITIONING FOR MILLIVOLT DC MEASUREMENT (Figure 3-1)

In the millivolt DC mode, the voltage being measured is connected directly to the input buffer amplifier A1 (p/n 38-64). The input amplifier A1 is connected potentiometrically to provide high input impedance at gains of 300, 30 and 3 on the Low, Medium and High ranges respectively. With a full-scale input of 19.99 mv in the low millivolts mode and an amplifier gain of 300, the output of A1 (p/n 38-64) will be 5.997 volts. Thus, after preamplification, the scaling of the unknown input voltage is 3 mv/digit to be displayed.

An input filter, consisting of R2, R4, C3 and C4 on the Amplifier Assembly is activated by switching in the filter switch (S1), mounted on the front panel. The input filter gives 60 db of rejection at 60 Hz.

## SIGNAL CONDITIONING FOR VOLTS DC MEASUREMENT (Figure 3-2)

The volts DC mode has three ranges of 19.99, 199.9 and 1000 volts full scale. An attenuator divides the input voltage by 100 in the 19.99-volt range, 1000 in the 199.9-volt range and 10,000 in the 1,000-volt range.

The gain of the input buffer amplifier A1 (p/n 38-64) is set at X30 by the feedback network consisting of R14, R28, R30, and R32. The voltage applied to the X-3 input is scaled by the DC Voltage Input Attenuator and the output of the Buffer Amplifier will increase three millivolts for every digit appearing in the readout.

## SIGNAL CONDITIONING FOR CURRENT MEASUREMENTS (Figure 3, 4, & 5)

Current measurements are made with the

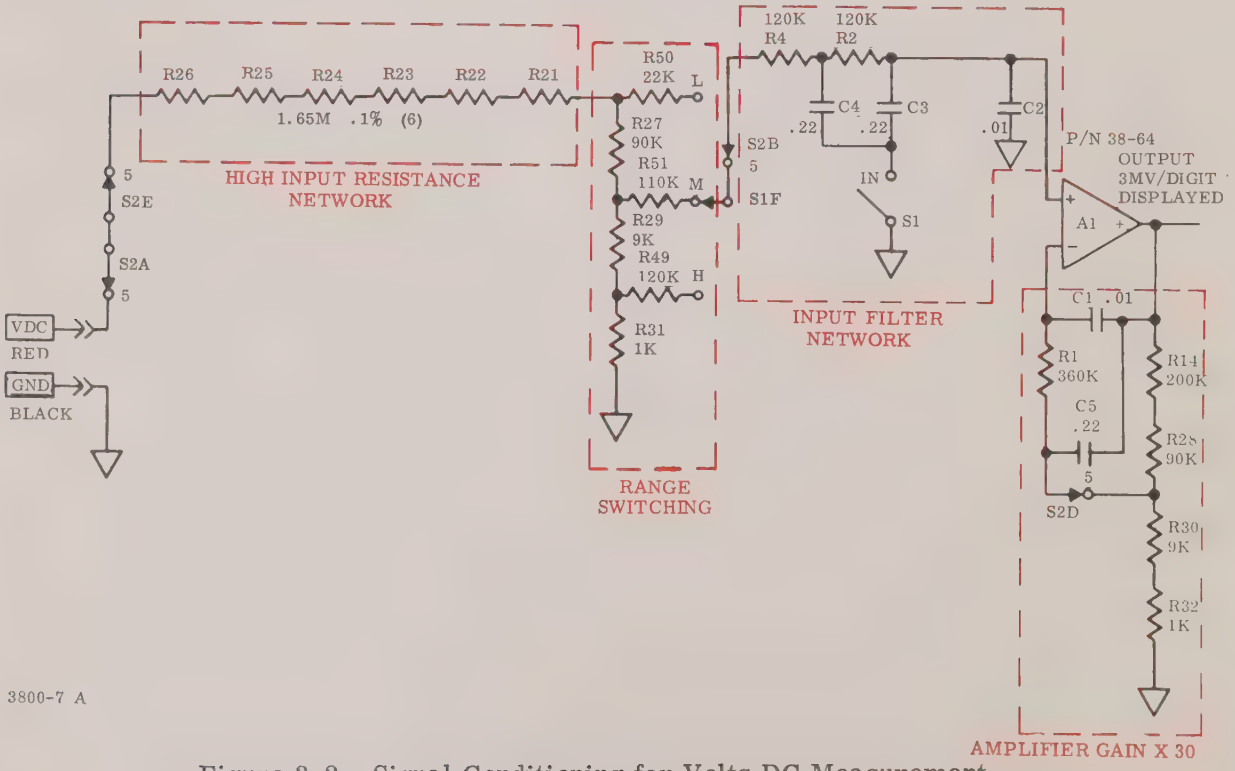



Figure 3-2. Signal Conditioning for Volts DC Measurement

Series X-3 by sensing the voltage drop across a precision resistor switched in series with the unknown current. The current sensing resistor in the milliampere medium range (M) is 1Ω. At full scale this provides a voltage drop of 199.9 millivolts at the input to the buffer amplifier which has a fixed gain of X30. Input scaling of the signal by the buffer and associated circuitry is the same as the other functions and provides 3 mv/digit at the output of buffer amplifier A1 (p/n 38-64). In the milliamperes, low range position (L), the resistor becomes 10Ω to provide the same full-scale voltage drop of 199.9 millivolts. Sensing resistors continue to increase in value by a factor of 10 as the current ranges decrease by factors of 10. However, in nanoampere ranges, the full-scale voltage drop is 19.99 millivolts rather than 199.9 millivolts and the gain of the buffer amplifier is increased to X300 to avoid using a sensing resistor of unreasonably high value. With a full scale voltage drop of 19.99 and an amplifier gain of X300, the scaling factor at the output of amplifier A1 is maintained at 3 mv/digit displayed.

## SIGNAL CONDITIONING FOR VOLTS AC MODE (Figure 3-6)

Series X-3 measures AC voltages from 20 Hz to 700 M Hz with an AC probe utilizing AC coupling and a thermionic diode. A front panel AC zero control is used to nullify diode contact potential. An input attenuator divides the VAC input into full-scale ranges of 19.99 VAC, 199.9 VAC and 1999. VAC (maximum voltage on the high range is 300 VAC).

The input voltage to the buffer amplifier A1 is scaled to 199.9 millivolts (full-scale) by

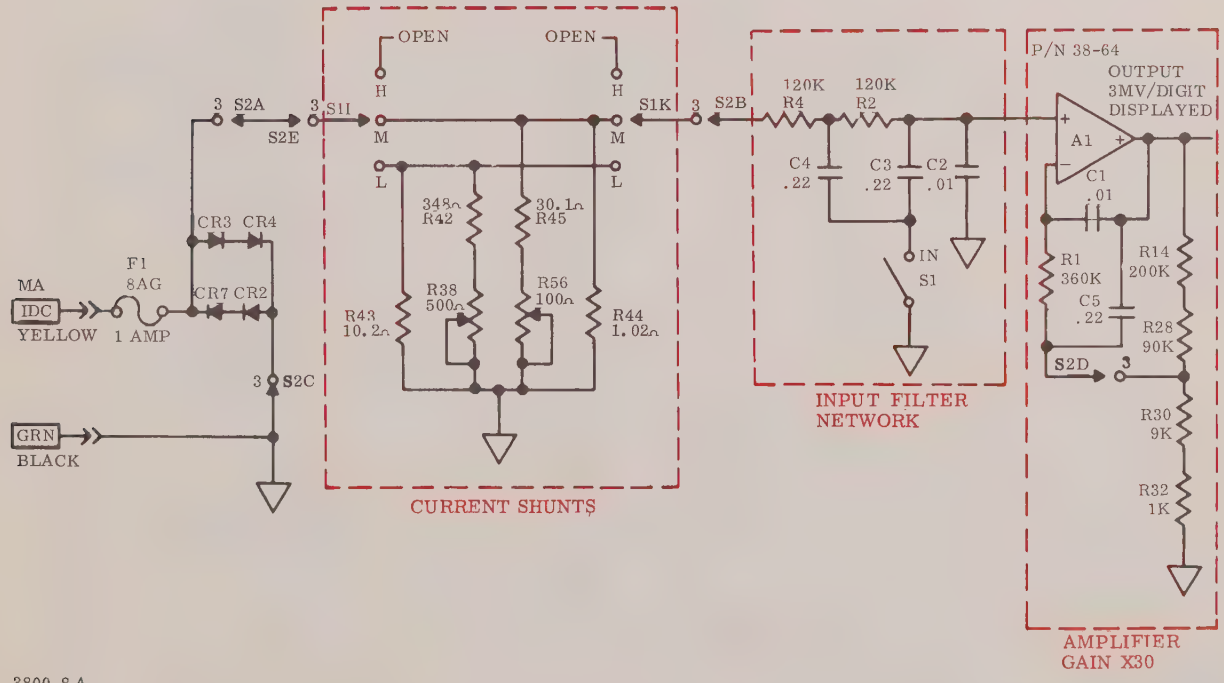



Figure 3-3. Signal Conditioning for Milliampere Measurement

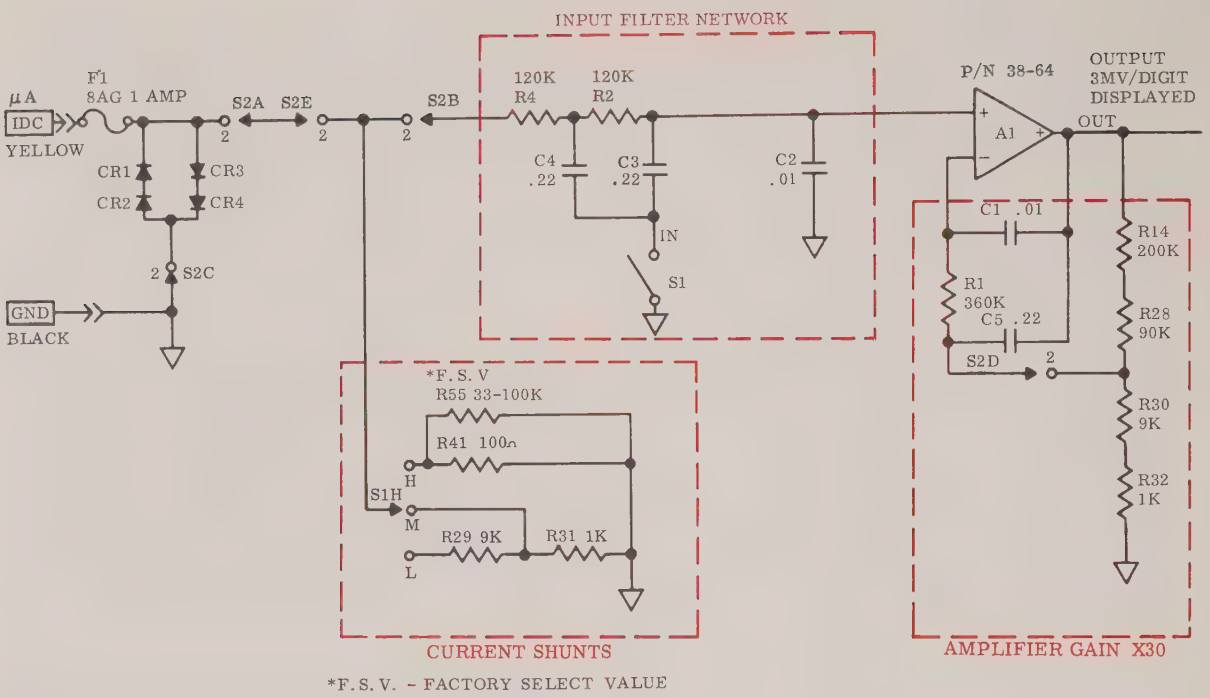



Figure 3-4. Signal Conditioning for Microampere Measurement

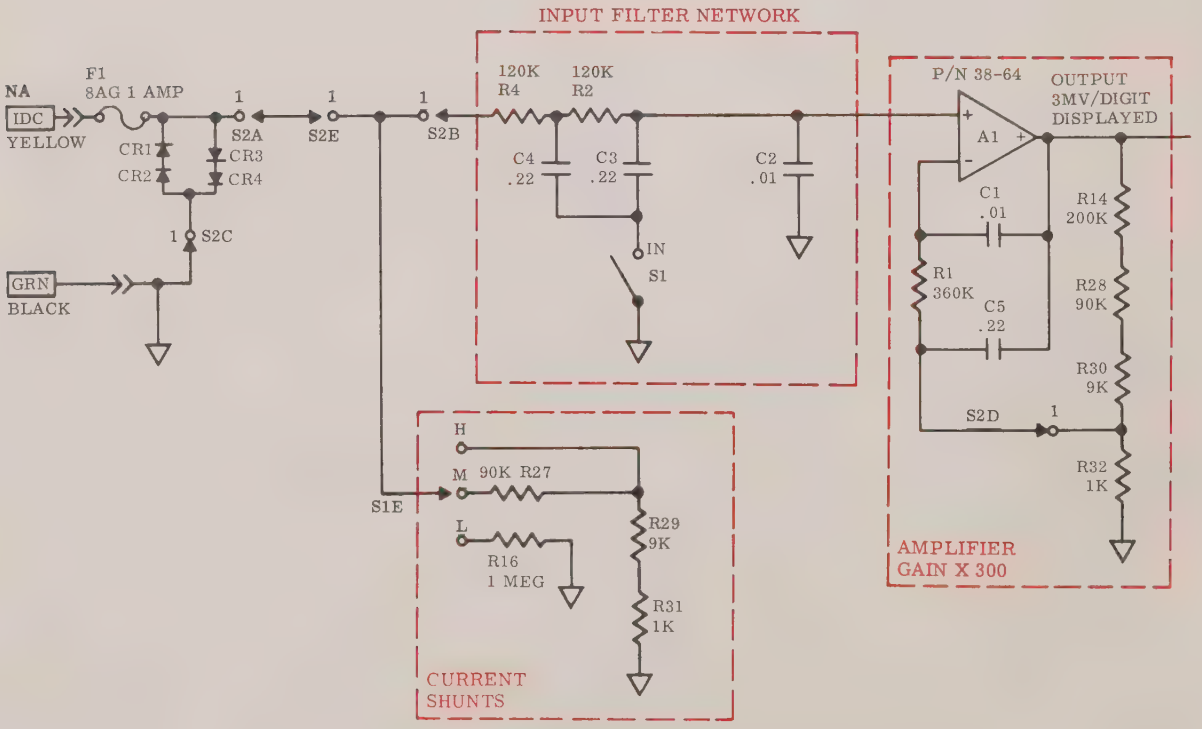



Figure 3-5. Signal Conditioning for Nanoampere Measurement

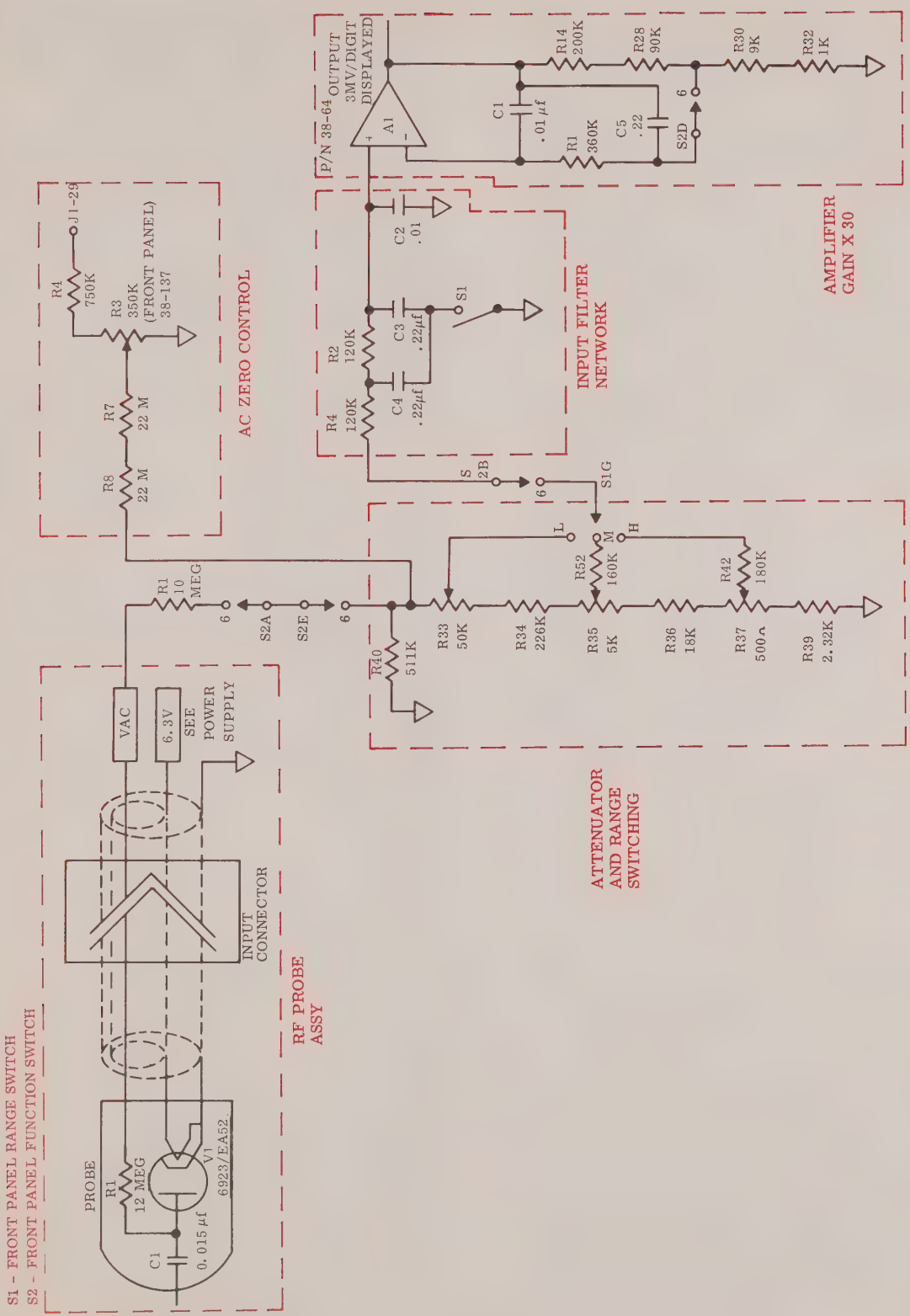



Figure 3-6. Input Probe and Attenuator Board Signal Conditioning for VAC Measurement

each of the attenuator steps and the gain of A1 is set at X30. The scaling and conditioning at the output of A1 is 3 millivolts per digit displayed.

A vacuum tube diode is used in the probe assembly as a rectifier because of its superior high frequency and high voltage (300 v rms max.) performance. The tube filament is energized by a regulated 6.3-volt DC source to eliminate power line interference and to provide good zero stability. The probe is of coaxial design with the diode, a capacitor and resistor located in the probe tip. A phone plug at the end of a double-shielded coaxial cable connects the probe to the X-3. High input resistance (12 MEGΩ) and low shunt capacitance (3 pf) minimize circuit loading.

The probe circuit acts as a negative clamp. The input voltage will have its positive excursion clamped to ground without materially affecting the waveform. The purpose here is to establish a DC voltage component proportional to the positive peak above average value of the input. This action results in a DC voltage at the junction of the diode anode and resistor R1 which is negative with respect to ground. The AC component of the input is removed by the input filter (S1) which must be in the circuit.

SIGNAL CONDITIONING FOR RESISTANCE MEASUREMENTS (Figures 7, 8, & 9)

Resistance measurements are made by measuring the voltage drop across a resistor under test (Rx) through which a known stable current is passing (Figure 3-7).

To read the proper value, current passing through Rx must be properly switched so that one unit of the resistance being measured is equal to one digit displayed in the readout.

To accomplish this one-to-one relationship, the current is changed in precise decade steps depending on the range in use (i.e. 10 ma, 1 ma, 0.1 ma, etc).

The internal current source is composed of a regulated voltage power supply and a series precision resistor. This precision resistor is different for each range and is changed by the range switch, (S1). The regulated voltage supply consists of A1 (TD401) which forms a differential amplifier, and transistor Q1 which is a series regulator. The output of Q1 is adjusted by R2, a 5KΩ potentiometer, which is part of a voltage divider connected to the +85 volts reference supply. Any change in the reference voltage will be cancelled by a corresponding change of current through the test resistor.

Because Rx is in series with the precision resistor in the constant current source (Figure 3-7), a change in the value of Rx will tend to change the current through Rx, even though the precision resistor is much larger than Rx. A change in current will produce an inaccurate reading. To maintain a stable current with various values of Rx,

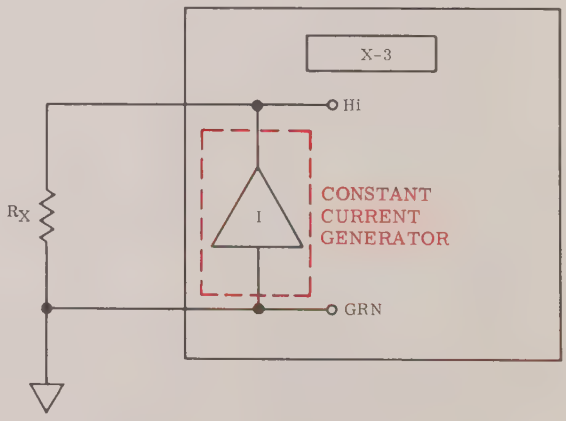
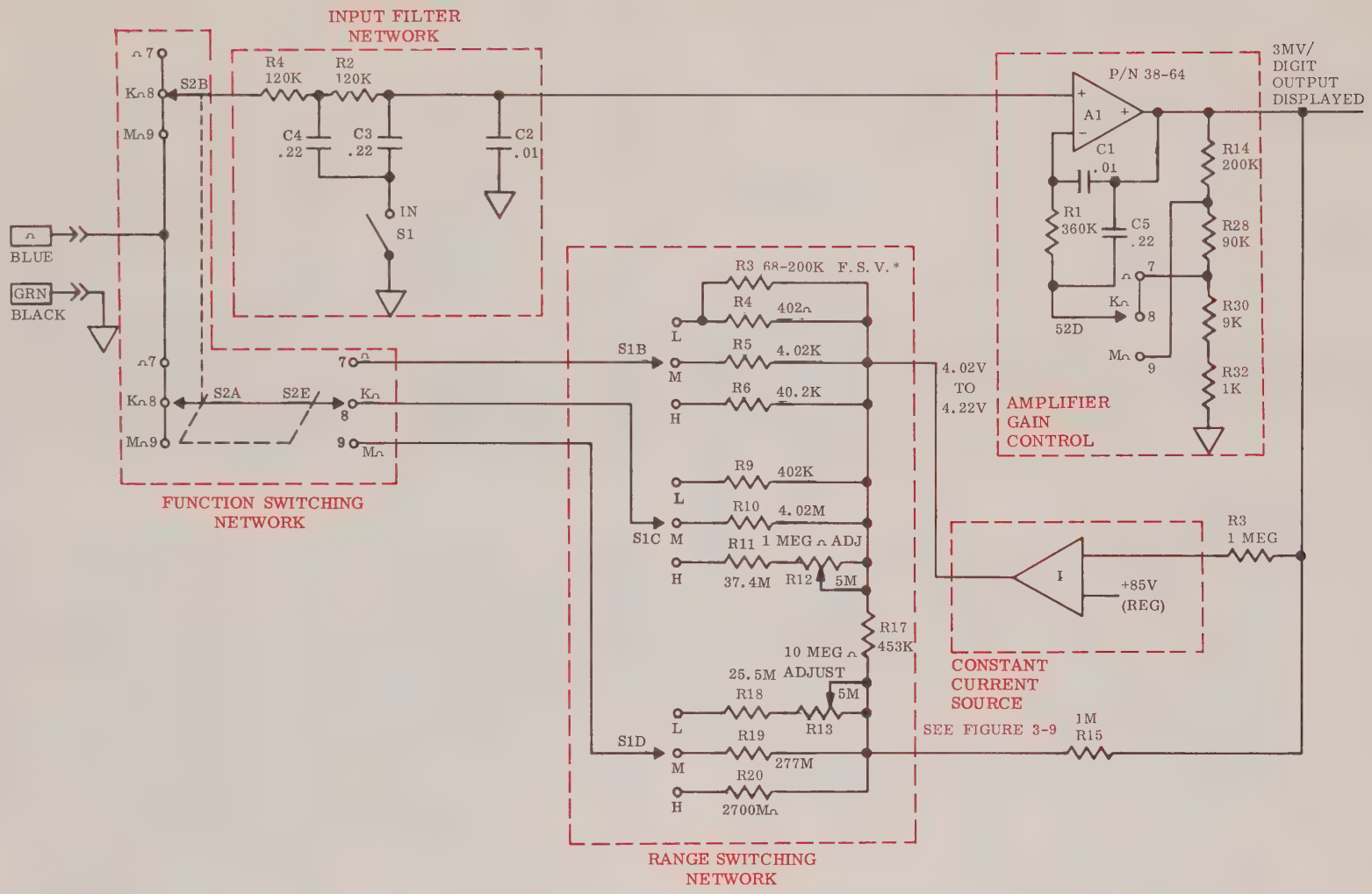



Figure 3-7. Simplified Diagram, Resistance Measurement




*F.S.V. - FACTORY SELECT VALUE

Figure 3-8. Signal Conditioning for Resistance Measurement

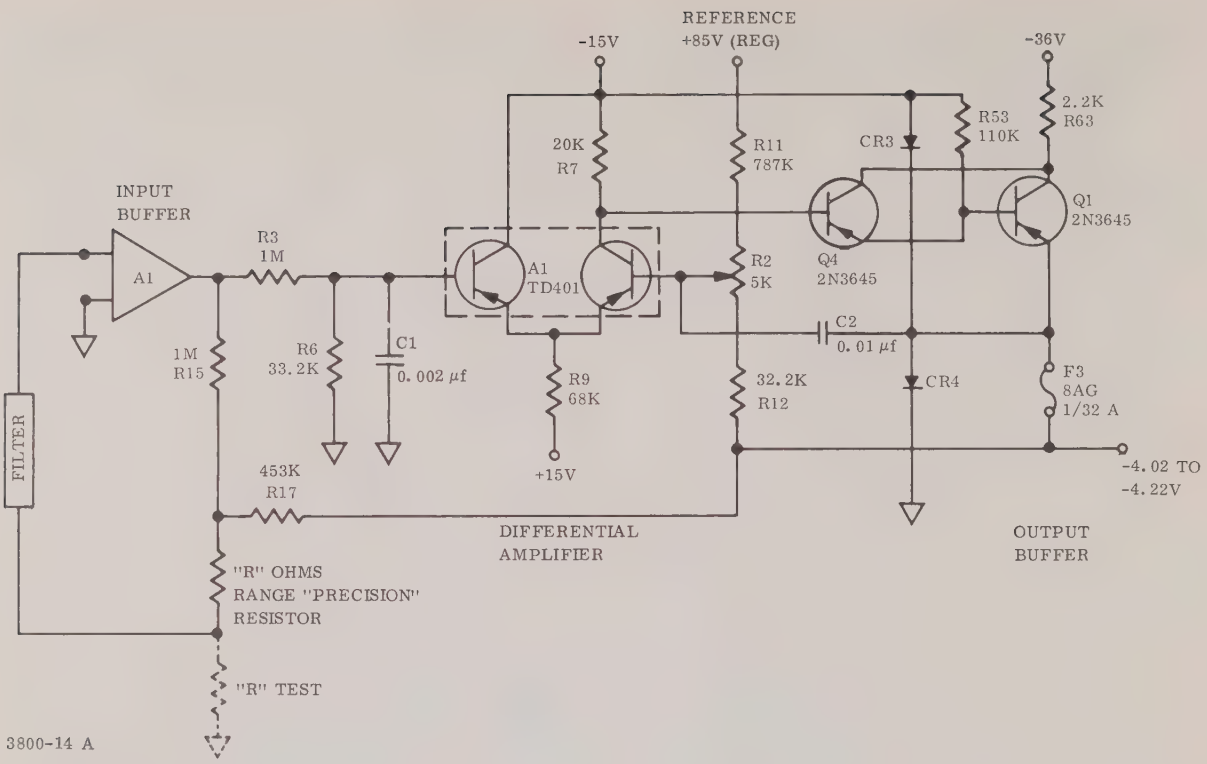



Figure 3-9. Constant Current Source

a resistor network (R3, R6, R16, and R15) is employed to sum together the outputs of the buffer amplifier (A1) and the differential amplifier portion of the constant current source. The values in this resistor network are selected so that any increase in Rx will also increase the voltage source output, thus keeping the current through Rx the same. This true constant current assures precise, linear readings of Rx.

## DIGITIZING SECTION (Figure 3-10)

The normalized signal from the attenuator section enters the digitizing section in the form of a DC voltage having an amplitude of 3 mv for each digit displayed in the readout. A block diagram of the digitizing section is shown in Figure 3-10. The input to this section is labelled 'from buffer amplifier output' in Figure 3-10. When the readout display is +1000 this signal will be +3 volts; when the readout display is -1000 the signal will be -3 volts.

A minus polarity input signal is fed directly to the comparator amplifier (A3). A positive polarity input signal is inverted by a polarity inverting amplifier (A2) causing the comparator amplifier (A3) to see only negative input signals.

To make a reading with the X-3, the signal coming into the comparator amplifier (A3) from the attenuator must be balanced or cancelled out by a feedback signal from the Digital-to-Analog (D/A) Feedback network. A difference between the input signal and the feedback network generates UP- or DOWN-pulses that drive the feedback network so as to reach a balance between the two signals. The output of the comparator amplifier (A3) feeds through two channels (UP- or DOWN-

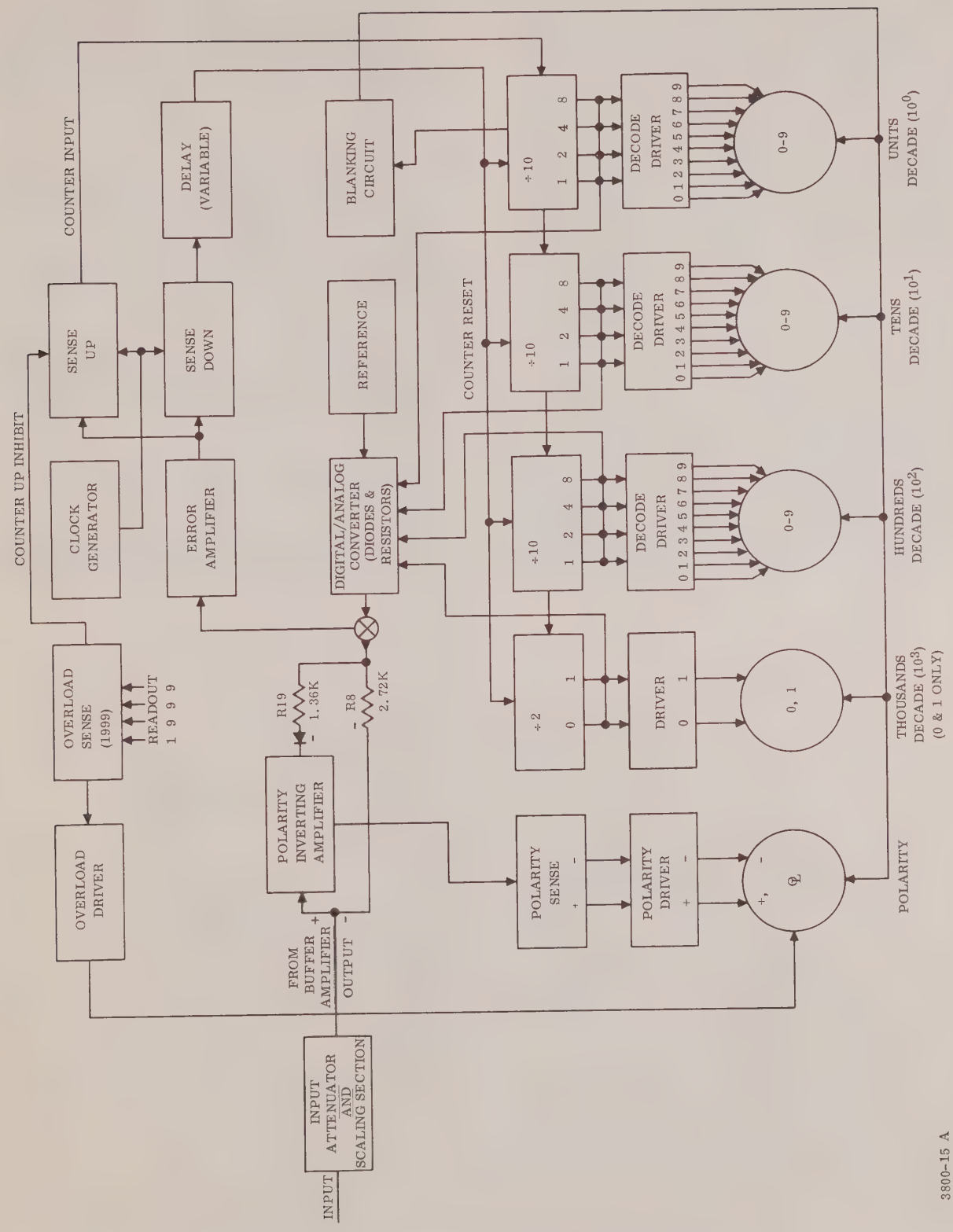



Figure 3-10. Block Diagram, Digitizing Section

drive). UP- pulses are fed into the input of the least significant decade ($10^0$) and make the D to A feedback network count up. UP- pulses continue to step the right-hand decade digit-by-digit until a nine is reached whereupon the decade returns to zero and transfers a pulse into the next significant decade ($10^1$) and so on until a balance, or 1999 overload is reached. This digit-by-digit counting also changes the readout display, which is controlled by decade drivers.

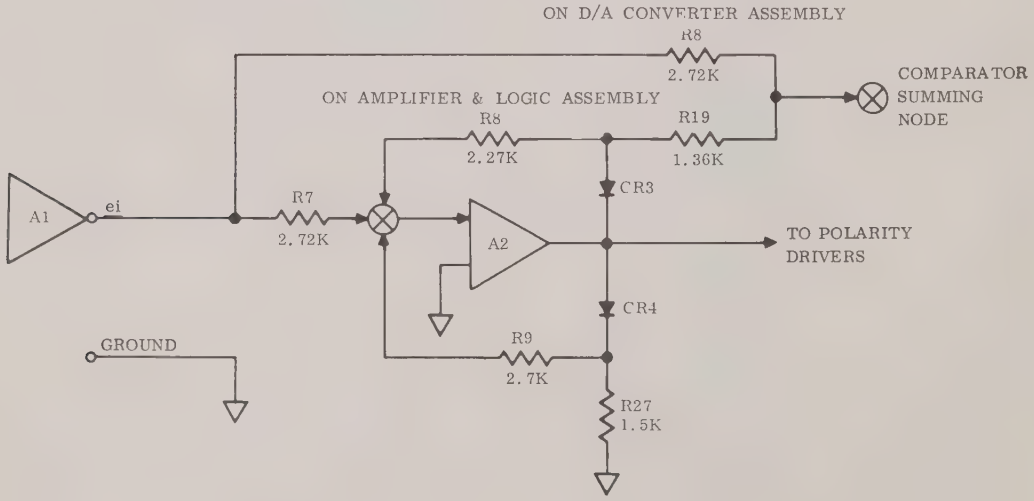
DOWN-pulses are delayed by routing them to a variable delay controlled by a display control pot on the front panel. As the ON DISPLAY potentiometer is rotated clockwise, the delay is lengthened to a maximum of about two seconds. The first DOWN-pulse triggers the delay circuit. At the end of the delay period, the D to A network is reset to zero. With all counters and the bridge set to zero, there is now an UP-pulse condition and the instrument counts up to the new reading. The clock operates at 25 KHz or 40 microseconds per bit. A full scale input of 1999 will take about 80 milliseconds to reach a reading.

During the UP-count period, the blur of numbers is eliminated through the use of a blanking circuit. The blanking circuit consists of a series of buffers and a rectifier to sense the counter is running and to shut off the B+ to the NIXIE tubes.

When a 1999-condition exists in the readout, a sensing circuit turns on the overload indicator (OL) and simultaneously shuts off the UP-pulses.

POLARITY SENSING (Figure 3-11)

The polarity sensing circuit furnishes a negative signal to the comparator summing node




3800-16 A

Figure 3-11. Polarity Sensing Circuit

for either a positive or negative input signal. For negative inputs, the signal is routed to the comparator summing node. For positive signals, the input is inverted in a polarity inverting amplifier (A2).

Automatic polarity switching uses a DC operational amplifier for signal routing.

With a positive input ($+e_i$), the output of A1 will be negative and current (+i) flows through resistors R7 and R8 (Amplifier and Logic Assembly) as shown in Figure 3-11. This current (+i) causes a voltage drop across R8 (Amplifier and Logic Assembly), equal to $+e_i$ but opposite in polarity. The voltage drop causes a current to flow through resistor R19, out of the comparator amplifier (A2) summing node. At the time, $+e_i$ causes a current to flow into the comparator summing node through Resistor R8 (D/A Converter and Reference Assembly). Because the value of R8 (D/A Converter and Reference Assembly) is twice the value of R19, the net effect is to cause a current to flow out of the comparator summing node with a positive signal input.

When there is a negative input ($-e_i$), the output of A2 will be positive and diode CR3 is reverse biased and cut off. Therefore, no current will flow through R19 into the comparator summing node.

## POLARITY DRIVERS (Figure 3-12)

The output of Amplifier A2 in the polarity sensing circuitry is applied to transistor circuitry which energizes the positive and negative polarity symbols in the readout.

As current flow through R25 increases in a positive direction, a trigger circuit consisting of transistors Q4 and Q5 changes state

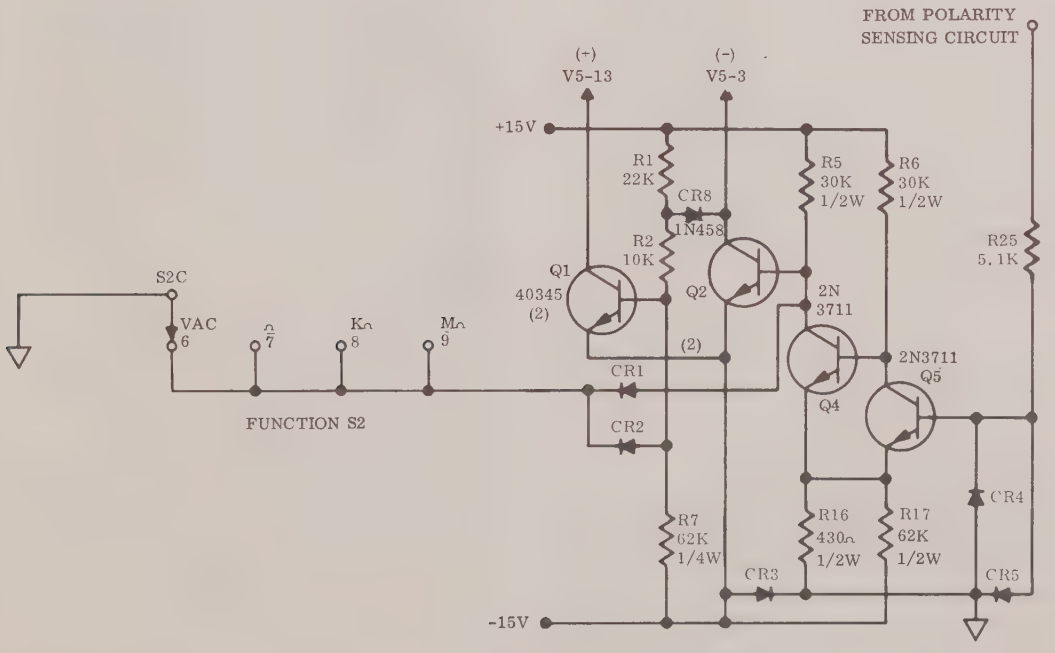



Figure 3-12. Polarity Driver Circuitry

to turn on transistor Q2 to energize the minus NIXIE symbol in the readout. Because polarity amplifier A2 inverts the DC input, the symbol is correct.

When the DC signal input voltage become positive, the trigger of circuit changes state causing Q2 to turn off (-NIXIE) and Q1 to turn on energizing the positive polarity NIXIE.

In those functions where polarity indication is not needed (VAC, Ω, KΩ, MΩ), level "C" of the function switch ties the base of Q1 and Q2 to ground ensuring no indication.

## REACHING A READING

The way an X-3 arrives "at Balance" when measuring its input is controlled by the condition at the comparator summing point. The net current from the polarity sensing circuit is summed with feedback current from the D/A converter at the comparator summing node. When the two currents are equal, balance has been achieved. An unbalance exists when the readout displays a voltage different from the actual input voltage. In the unbalanced condition, the two currents at the comparator summing node are unequal. The comparator output is then applied to the input of threshold detection circuits and UP-DOWN logic which precede the counting decades.

SN7400N Quad nand gates are used for logic and timing functions in the X-3 Series. 7400 logic is defined as follows:

Low Voltage = Logical 0
High Voltage = Logical 1

Supply voltage to the chips is a nominal +5V DC. A high "1" input is required at both the input terminals of a gate to produce a logical "0" level at the output. Schematics of the internal circuitry of the gates of the SN7400 Quadruple Assembly, SN7490 Decade Counter, and SN7441 BCD-to-Decimal Decoder are shown in Figure 3-13, 3-14, and 3-15, respectively.

## DIGITAL SECTION, GENERAL OPERATION (Figure 3-16)

The comparator output at the emitter of Q8 is zero when the DVM is at balance, positive when the input is greater than the A-to-D feedback network and negative when the input is less than the A-to-D feedback network. The positive DC error signal is modulated by the clock at gate A4-A. Gates A4-A, A4-B, and A4-C, detect the positive error signal level and produce a series of UP-pulses, driving transistor Q16 and applying pulses to the input of least significant decade A4 (Pin 14) in the D-to-A converter section. The action continues, pulling in bridge resistors in a 1-2-4-8 format, until the bridge current equals the input current. The balanced current condition causes the error signal at

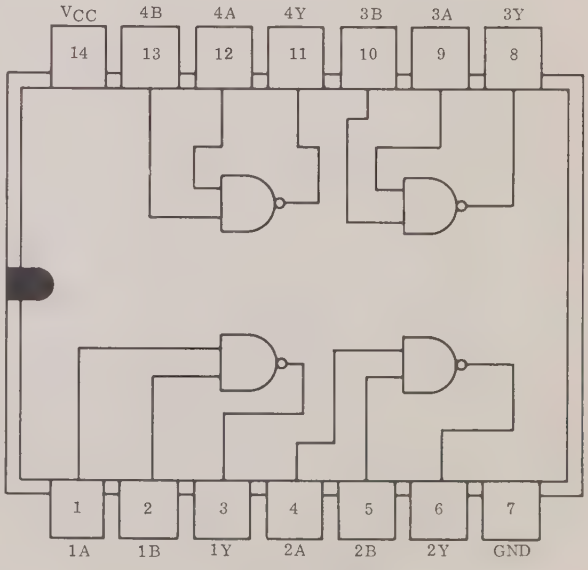



Figure 3-13. Type SN7400N Quadruple 2-Input Positive Nand Gate

TRUTH TABLES

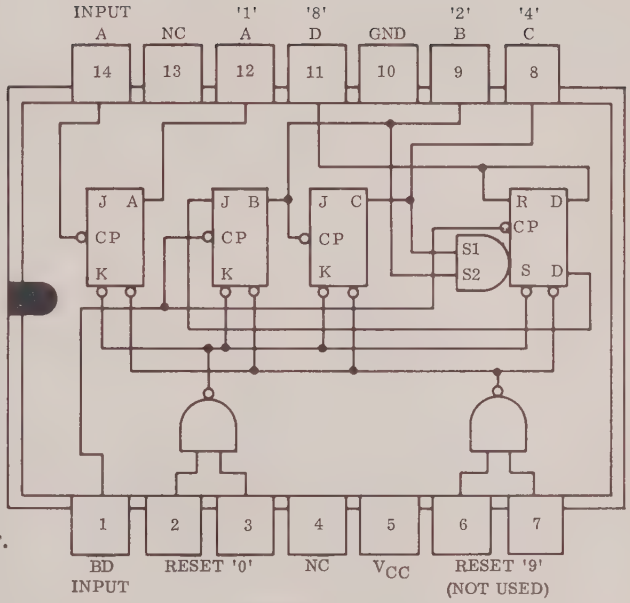
BCD COUNT SEQUENCE
(SEE NOTE 1)

| COUNT | OUTPUT | | | |
|---|---|---|---|---|
| | D | C | B | A |
| 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 0 | 1 |
| 2 | 0 | 0 | 1 | 0 |
| 3 | 0 | 0 | 1 | 1 |
| 4 | 0 | 1 | 0 | 0 |
| 5 | 0 | 1 | 0 | 1 |
| 6 | 0 | 1 | 1 | 0 |
| 7 | 0 | 1 | 1 | 1 |
| 8 | 1 | 0 | 0 | 0 |
| 9 | 1 | 0 | 0 | 1 |

RESET/COUNT (SEE NOTE 2)

| RESET INPUTS | | | | OUTPUT |
|---|---|---|---|---|
| $R_{0(1)}$ | $R_{0(2)}$ | $R_{9(1)}$ | $R_{9(2)}$ | D C B A |
| 1 | 1 | 0 | X | 0000 |
| 1 | 1 | X | 0 | 0000 |
| X | 0 | 1 | 1 | 1001 |
| 0 | X | 1 | 1 | 1001 |
| 1 | 1 | 1 | 1 | 1001 |
| X | 0 | X | 0 | COUNT |
| 0 | X | 0 | X | COUNT |
| 0 | X | X | 0 | COUNT |
| X | 0 | 0 | X | COUNT |

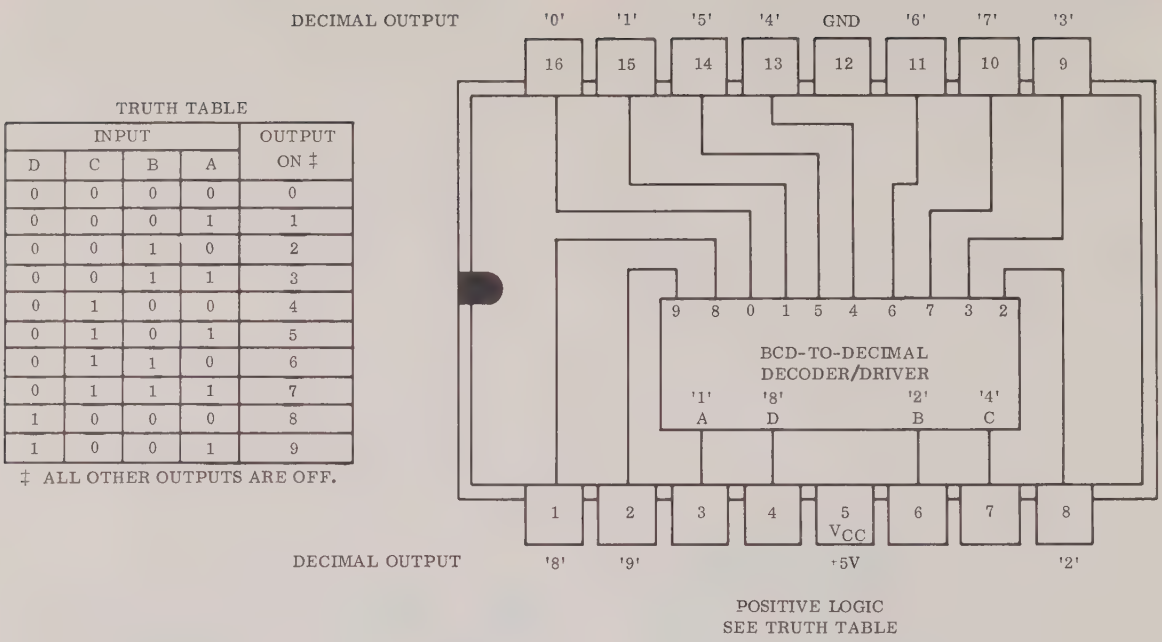
NOTES:
1. OUTPUT A CONNECTED TO INPUT BD FOR BCD COUNT.
2. X INDICATES THAT EITHER A LOGICAL 1 OR A LOGICAL 0 MAY BE PRESENT.




POSITIVE LOGIC
SEE TRUTH TABLES
NC—NO INTERNAL CONNECTION

3800-19 A

Figure 3-14. Type SN7490N Decade Counter


DECIMAL OUTPUT
'0' '1' '5' '4' GND '6' '7' '3'
16 15 14 13 12 11 10 9
9 8 0 1 5 4 6 7 3 2
BCD-TO-DECIMAL
DECODER/DRIVER
'1' '8' '2' '4'
A D B C
1 2 3 4 5 6 7 8
$V_{CC}$
DECIMAL OUTPUT
'8' '9' +5V '2'
POSITIVE LOGIC
SEE TRUTH TABLE

TRUTH TABLE

| INPUT | | | | OUTPUT ON ‡ |
|---|---|---|---|---|
| D | C | B | A | |
| 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 1 | 1 |
| 0 | 0 | 1 | 0 | 2 |
| 0 | 0 | 1 | 1 | 3 |
| 0 | 1 | 0 | 0 | 4 |
| 0 | 1 | 0 | 1 | 5 |
| 0 | 1 | 1 | 0 | 6 |
| 0 | 1 | 1 | 1 | 7 |
| 1 | 0 | 0 | 0 | 8 |
| 1 | 0 | 0 | 1 | 9 |

‡ ALL OTHER OUTPUTS ARE OFF.

3800-20 A

Figure 3-15. Type SN7441AN BCD-Decimal Decoder/Driver

Pin 6 of A3 (comparator amplifier) to be either zero or equivalent to less than one digit. At this time, the input to gate A4-D at pin 5 is below the threshold level and no further "up" count pulses are produced.

When the input is negative, the negative signal is inverted by gate A4-D and modulated by the clock at gate A5-C producing down-pulses. The output of gate A5-C triggers a one-shot multivibrator. The one-shot multivibrator determines how long the DVM holds the reading. By means of the ON DISPLAY potentiometer located on the front panel, the reset delay period can be adjusted (R1 in Figure 3-16) from 60 ms to 2 seconds. At the end of the delay period, a reset signal zeros the counting decades and the over-range flip-flop. The error signal at the output of the comparator amplifier A3 then becomes positive and results in UP-counts until the instrument arrives at a balance.

CLOCK PULSE GENERATOR (Figure 3-17)

The Clock pulses for the X-3 are generated by the astable stage formed by transistors Q2 and Q1 on the Main Board. The output of this astable stage is buffered by Q4, an emitter follower into A4 Pin 4 and 13, and A5 Pin 10. The output waveform of the Clock Pulse Generator may be monitored at TP6.

OVERLOAD SENSE CIRCUITRY (Figure 3-18)

When the readout displays the maximum reading in over-range or 1999, transistor Q17 is gated "on", biasing Q3 "on" and lighting the overload display in the readout (Ⓛ). Q16, the UP-pulse buffer is also biased on, disabling the UP-pulse channel. Transistor Q10 (Switch 1) is typical of "switches" S-2, S-3, and S-4.

## NOTES

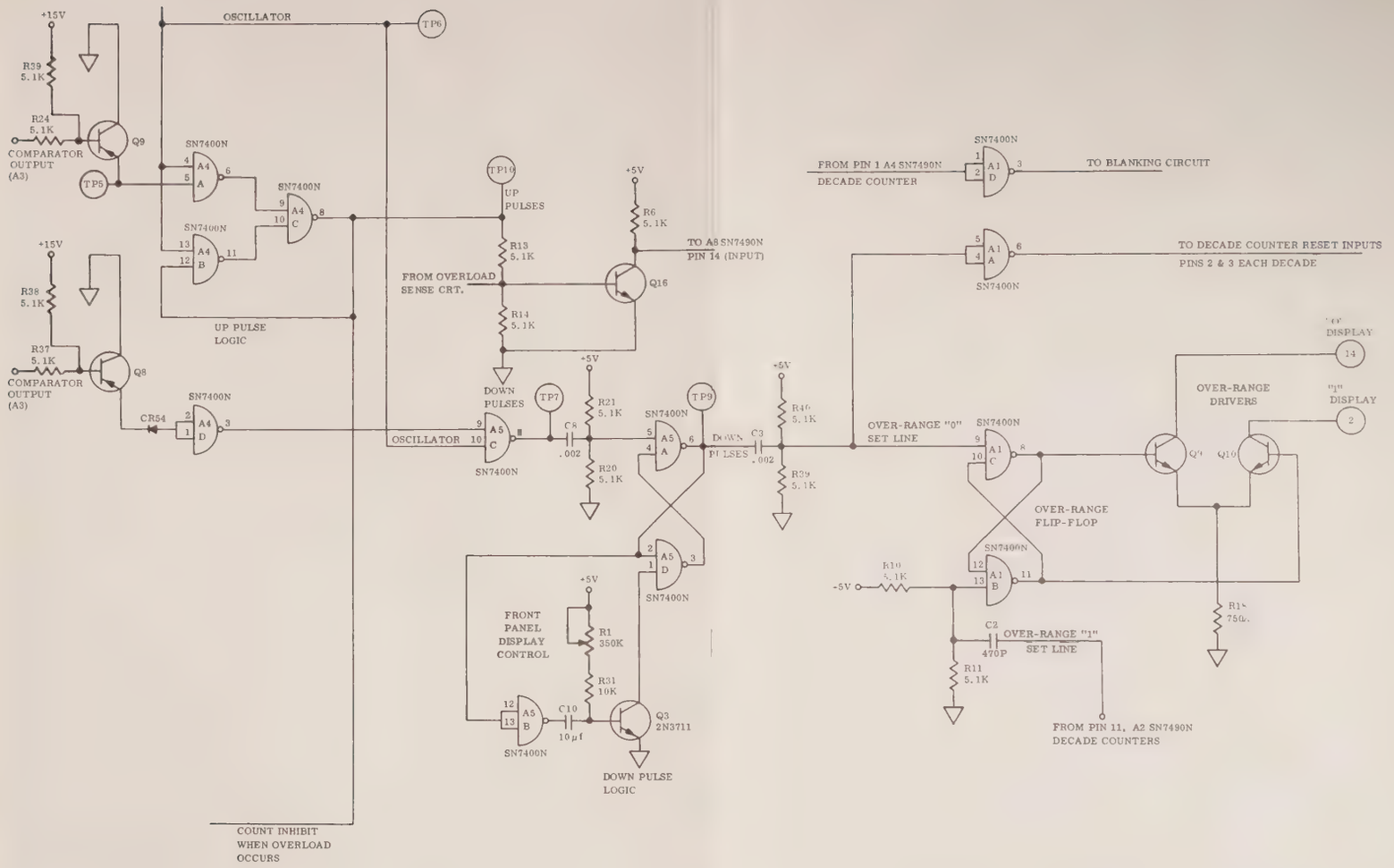
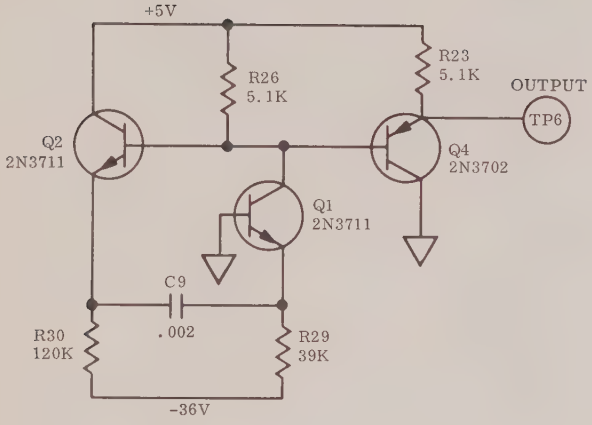
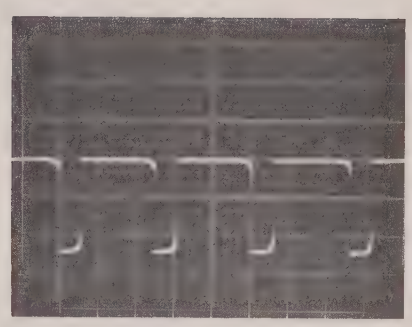


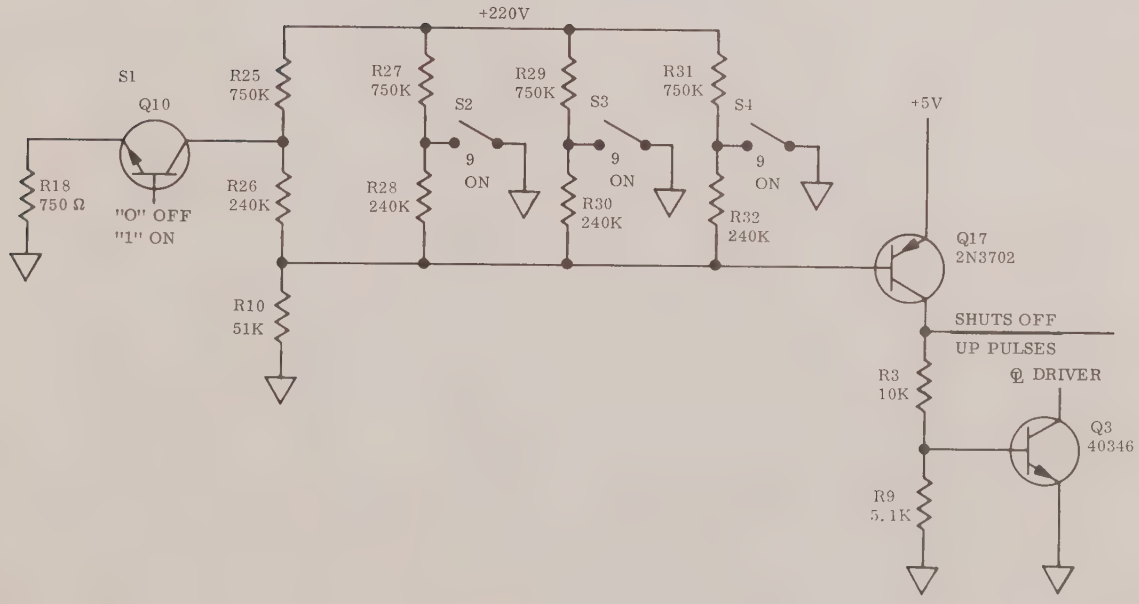

Figure 3-16. Up-Down Digital Logic



3800-22 A

Figure 3-17. Clock Pulse Circuitry




3800-23 A

Figure 3-18. Overload Sense Circuitry

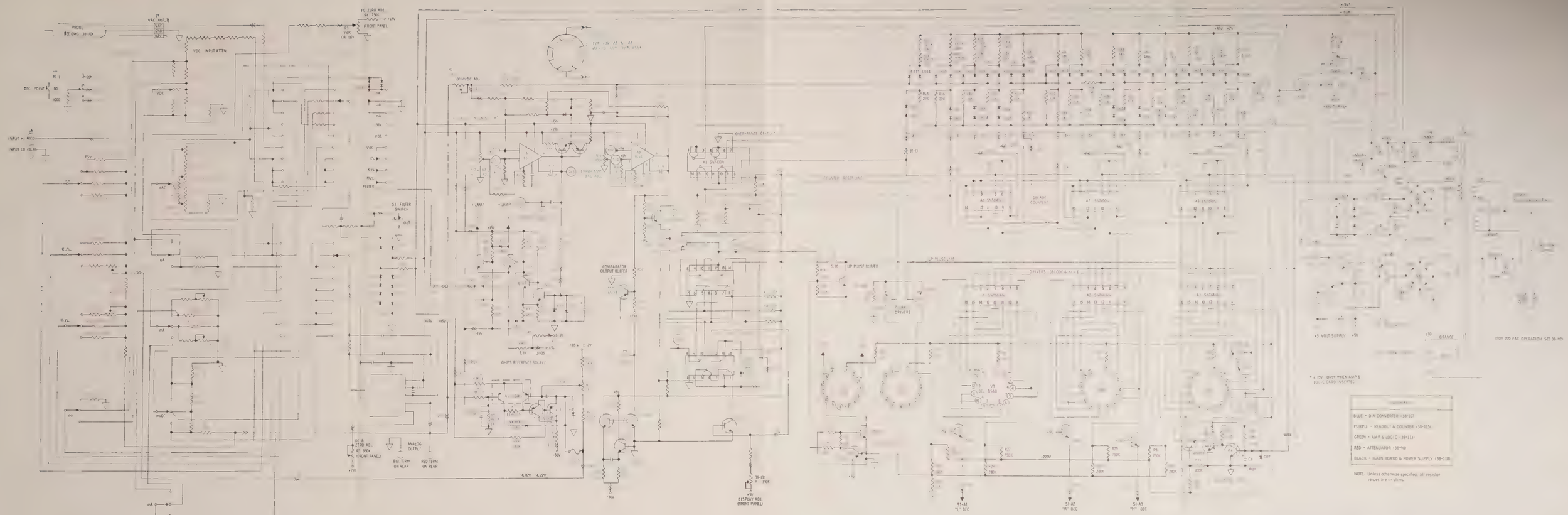



Figure 3-19. DVM Schematic Diagram

# CHAPTER IV

# CALIBRATION AND MAINTENANCE

## CALIBRATION

In the calibration instructions provided in this chapter, it is assumed that the instrument is in good working order and only requires calibration. If any components are defective, it may be difficult, if not impossible, to calibrate the instrument. If problems are encountered while performing the calibration procedures (i.e. the instrument will not meet the requirements set forth in the steps of the procedures), refer to the troubleshooting paragraph in this chapter.

### EQUIPMENT REQUIRED

1. A voltage standard between 10 MVDC and 1000 VDC.
2. A current source between 10 nA and 150 mA.
3. An audio voltage standard between 10 VAC, 400 Hz and 300 VAC, 400 Hz.
4. An ohms standard between 10Ω and 15 MegΩ.
5. An oscilloscope, Tektronix Model 502, or equivalent.
6. A Voltmeter capable of measuring 6.3 VDC.
7. An extension board, NLS P/N 1009-41.

NOTE

It should be noted that the error in making a measurement with the Series X-3 DVM can be as much as the stated accuracy of the instrument plus the accuracy of the standards used in its calibration.

### INITIAL PREPARATION

1. Remove the two screws on each side of cover and remove cover.
2. Remove Amplifier and Logic Assembly from instrument.
3. Insert extension board into J3 of Main Board Assembly.
4. Mount Amplifier and Logic Assembly on top of extension board by inserting amplifier and logic board pins into extension board. Use care to ensure proper pin alignment.
5. Plug power cord into 115 VAC, 50-400 Hz, single phase power source.
6. Turn ON DISPLAY control clockwise until an audible click is heard. Allow 30 minutes for instrument warm-up.
7. In each step, as applicable in the following procedures, allow warm-up time for each item of test equipment as per manufacturers requirements.

### PROCEDURE

1. Place ON DISPLAY potentiometer on front of instrument (right-most potentiometer) in center of its travel.
2. Place a voltmeter between 6.3V source (Figure 4-1) and signal LO input connector (black). Check to ensure that voltmeter indicates an input of 6.3 VDC ±8%.
3. Place range switch of instrument in H position.
4. Place function switch of instrument in mV position.

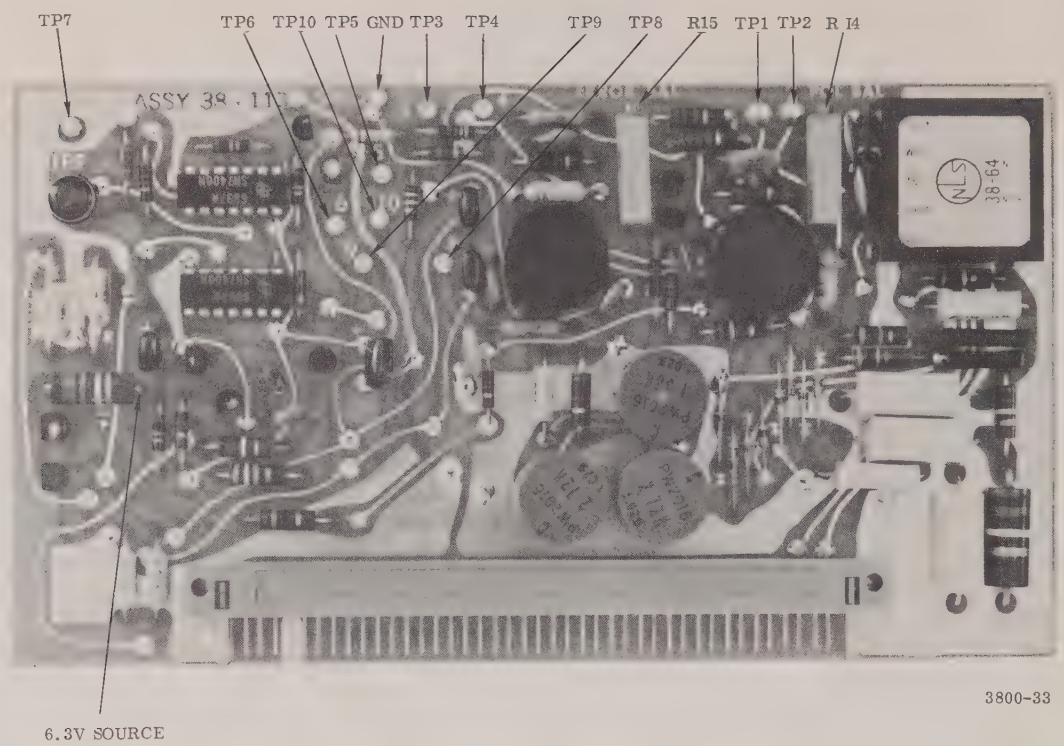



Figure 4-1. Amplifier and Logic Assembly Adjustments and Test Points

5. Connect input cables to connectors on front of instrument as follows (connectors are labeled on front panel):

   Red Cable.....HI

   Black Cable.....LO

   Black Cable (with probe)..AC PROBE

6. Connect input leads of oscilloscope to ANALOG OUTPUT connectors on rear of instrument.

7. Set oscilloscope sensitivity to 1 MV/CM. Oscilloscope should not be isolated from earth ground.

8. Connect red and black input leads together.

9. Set R14 and R15 fully counterclockwise (Figure 4-1).

10. Rotate DC and OHMS ZERO potentiometer on front of instrument (center potentiometer) until oscilloscope indicates a zero reading.

11. Connect input leads of oscilloscope to TP2 of Amplifier and Logic Assembly, 38-113 (Figure 4-1), and black analog output terminal.

12. Set oscilloscope sensitivity to 1 MV/CM and observe DC level.

13. Change oscilloscope lead from TP2 to TP1 and adjust R14 (Figure 4-1) until oscilloscope shows the same DC level as observed in Step 12.

14. Change oscilloscope lead from TP1 to TP4 and observe DC level.

15. Change oscilloscope lead from TP4 to TP3 and adjust R15 (Figure 4-1) until oscilloscope shows the same DC level as observed in Step 14.

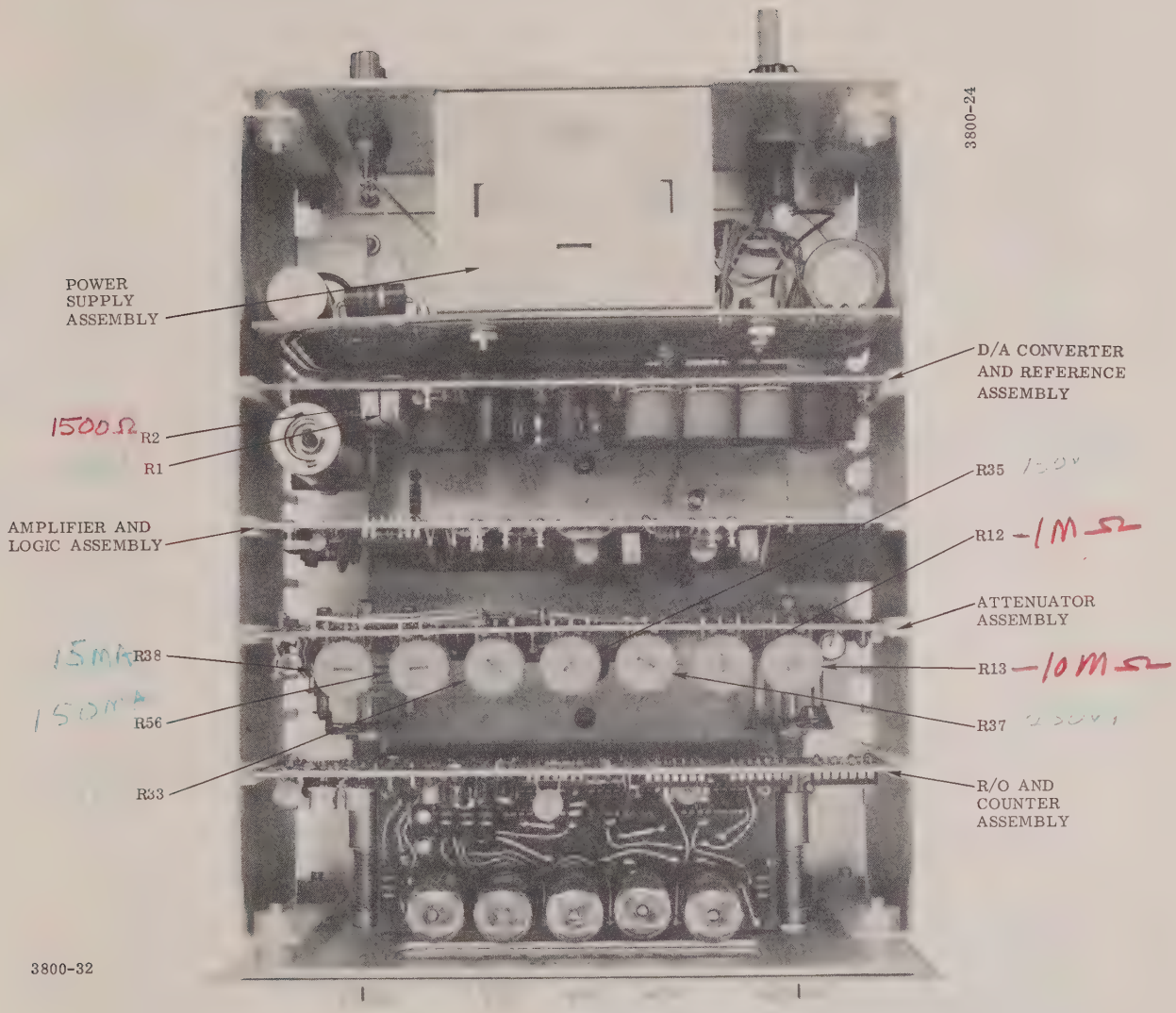



Figure 4-2. DVM Top View

16. Disconnect oscilloscope leads.

17. Connect red and black input leads to voltage standard. Apply approximately 150 mV.

18. Increase and decrease input voltage to see that DVM will count up one digit at a time to plus or minus 10 digits then count down one digit at a time and return to zero. If instrument does not, repeat Steps 6 thru 18.

19. Connect red and black input leads together.

20. Adjust DC and OHMS ZERO potentiometer if necessary until readout displays all zeros.

21. Place range switch in M position.

22. Connect red and black input leads to voltage standard. Apply approximately -150 mV.

23. Reverse polarity of signal input and check to see that the numerical value displayed in readout is identical (±2 digits), in either polarity, with the same voltage applied.

24. Instructions for range calibration in each mode of operation are contained in Figures 4-3 thru 4-6.

25. When calibration is completed, replace Amplifier and Logic Assembly and cover.

## MAINTENANCE

If the instrument is malfunctioning after carefully following the calibration instructions set forth in the preceeding paragraphs, maintenance will be required. The following troubleshooting data should enable the technician to isolate the cause of malfunction and thereby effect the replacement of the defective component/s.

## ACCESS TO COMPONENTS

The R/O and Counter Assembly, Amplifier and Logic Assembly and D/A converter and Reference Assembly are plug-in modules, easily removed by lifting them out of their matching connectors in the Main Board Assembly.

The Attenuator Assembly is also a plug-in module but, prior to removal the range switch knob and function switch knob must first be pulled away from the front panel and held away by the insertion of a small block of wood or even a pencil. By this action, the switches' shafts are disengaged from the switches which are located on the Attenuator Assembly.

To gain access to the power supply board assembly components, remove the four screws attaching the rear plate to the transformer, the four screws attaching the rear plate to the sides of the chassis and the two screws attaching the rear plate to the bottom of the chassis. The rear plate may then be lowered and the components are accessable.

## TROUBLESHOOTING

### Equipment Required

1. A voltmeter capable of measuring between 50 MVAC & 5 VAC and ±0 VDC and ±40 VDC.

2. An oscilloscope, Tektronix Model 502, or equivalent.

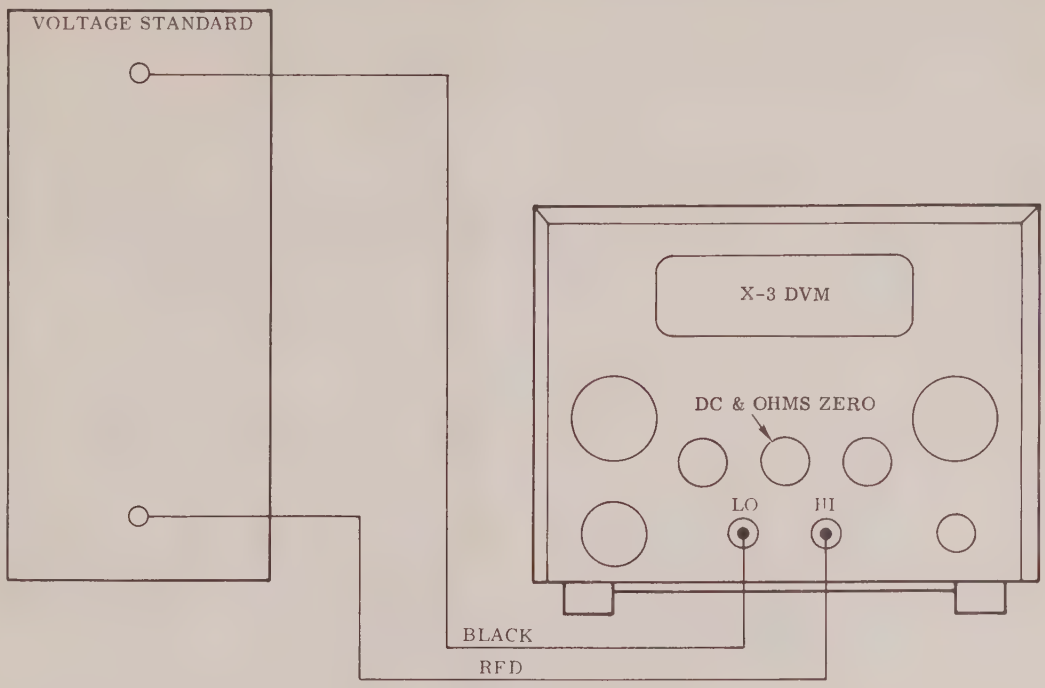
3. A voltage standard between ±1 VDC and ±5 VDC.

### Initial Preparation

1. Remove the four screws attaching the hood to the main chassis.

2. Gently withdraw hood from the instrument's main chassis.

3. Plug power cord into 115 VAC, 50-400 Hz,



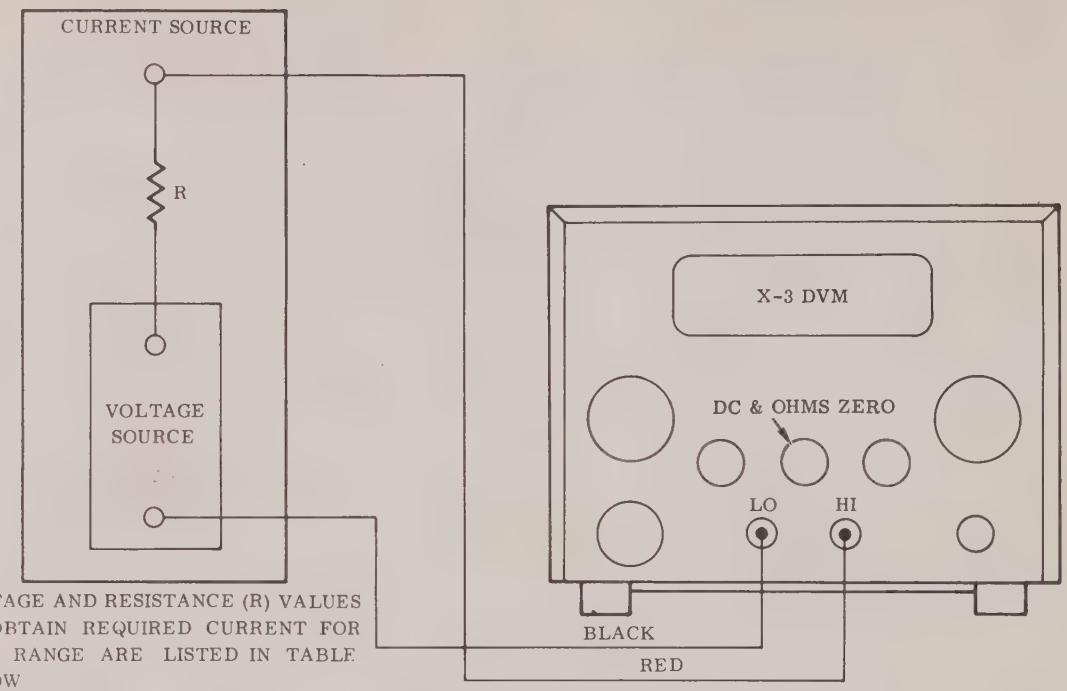

NOTE

AFTER
~~PRIOR TO~~ EACH RANGE OR FUNCTION CHANGE, ZERO THE READOUT IN MVDC OR VDC MODE (REFER TO CHAPTER II, ZEROING THE READOUT MVDC or VDC Zero).

PROCEDURE

| FUNCTION SWITCH POSITION | RANGE SWITCH POSITION | APPLY APPROXIMATELY | ADJUST | LOCATION (Figure No.) | READOUT TO DISPLAY VOLTAGE APPLIED, WITHIN |
|---|---|---|---|---|---|
| mV | H | 1500 mV | NONE | - - - | 0.1% RDG + 0.1% F.S. |
| mV | M | 150 mV | R1 | 4-2 | 0.1% RDG + 0.1% F.S. |
| mV | L | 15 mV | NONE | - - - | 0.2% RDG + 0.5% F.S. |
| VDC | L | 15 VDC | NONE | - - - | 0.1% RDG + 0.1% F.S. |
| | | WARNING HIGH VOLTAGE | | | |
| VDC | M | 150 VDC | NONE | - - - | 0.1% RDG + 0.1% F.S. |
| VDC | H | 950 VDC | NONE | - - - | 0.1% RDG + 0.2% F.S. |

Figure 4-3. MVDC and VDC Calibration




VOLTAGE AND RESISTANCE (R) VALUES TO OBTAIN REQUIRED CURRENT FOR EACH RANGE ARE LISTED IN TABLE BELOW

NOTES

1. INSTRUMENT MUST FIRST BE CALIBRATED IN MVDC AND DC MODES.
2. PRIOR TO EACH RANGE OR FUNCTION CHANGE, ZERO THE READOUT IN THE CURRENT MODE (REFER TO CHAPTER II, ZEROING THE READOUT, Current Zero).

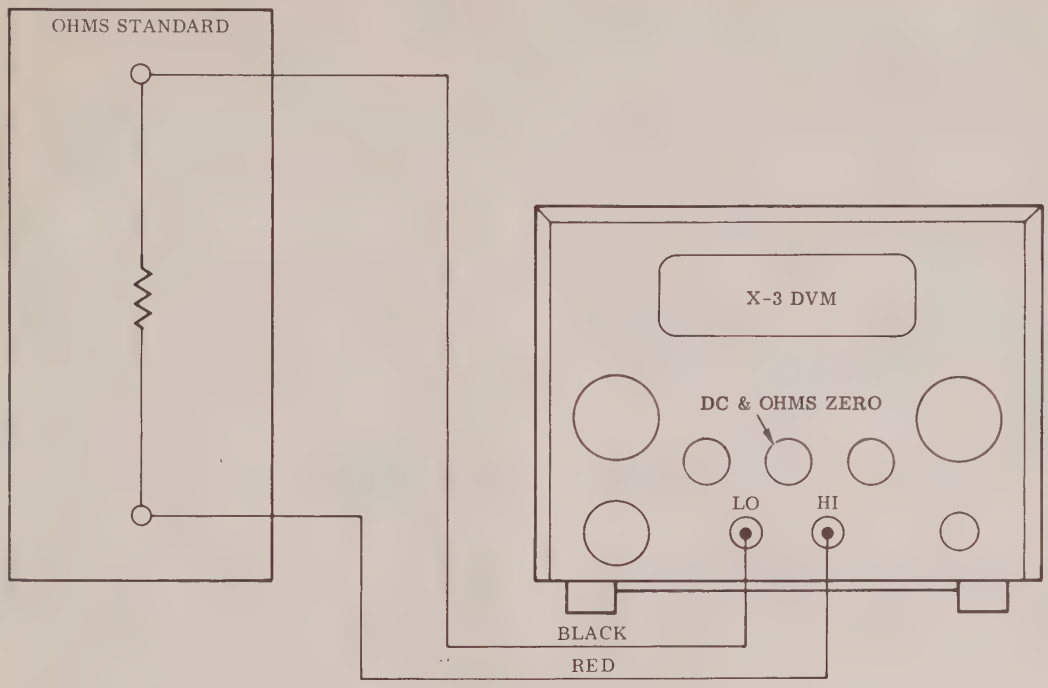
PROCEDURE

| FUNCTION SWITCH POSITION | RANGE SWITCH POSITION | CURRENT TO BE APPLIED | | | ADJUST | LOCATION (FIGURE NO.) | READOUT TO DISPLAY CURRENT APPLIED WITHIN | DVM INTERNAL RESISTANCE |
|---|---|---|---|---|---|---|---|---|
| | | | VOLTS (±0.02%) | R (±0.02%) | | | | |
| nA | L | 15 nA | 0.165 V | 10 M | NONE | --- | 20% RDG. + 0.5% F.S. | 1 MΩ |
| nA | M | 150 nA | 1.515 V | 10 M | NONE | --- | 5% RDG. + 0.5% F.S. | 100 KΩ |
| nA | H | 1500 nA | 1.515 V | 1 M | NONE | --- | 0.5% RDG. + 0.5% F.S. | 10 KΩ |
| μA | L | 15 μA | 15.150 V | 1 M | NONE | --- | 0.2% RDG. + 0.1% F.S. | 1002Ω |
| μA | M | 150 μA | 15.150 V | 100 K | NONE | --- | 0.1% RDG. + 0.1% F.S. | 1 KΩ |
| μA | H | 1500 μA | 15.150 V | 10 K | NONE | --- | 0.1% RDG. + 0.1% F.S. | 102Ω |
| mA | L | 15 mA | 15.150 V | 1 K | * R38 | 4-2 | 0.1% RDG. + 0.1% F.S. | 12Ω |
| mA | M | 150 mA | 15.210 V | 100 Ω | * R56 | 4-2 | 0.1% RDG. + 0.1% F.S. | 3Ω |

IF THIS ADJUSTMENT DOES NOT HAVE ENOUGH RANGE, CLEAN FUSE HOLDER ON ASSEMBLY AND MAKE SURE FUSE IS "BUSS" OR SIMILAR

CAUTION: DO NOT APPLY MORE THAN 200 mA or DAMAGE TO THE INSTRUMENT MAY RESULT.

Figure 4-4. Current Calibration



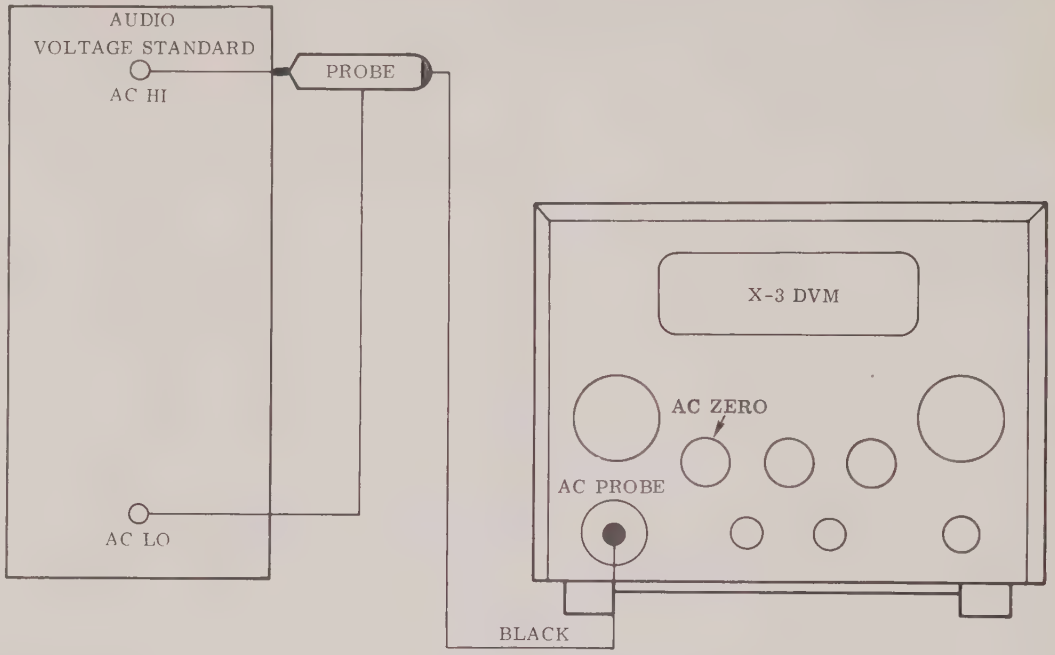

NOTES

1. INSTRUMENT MUST BE FIRST CALIBRATED IN MVDC & DC MODES.
2. PRIOR TO EACH RANGE OR FUNCTION CHANGE, ZERO THE READ-OUT IN OHMS MODE (REFER TO CHAPTER II, ZEROING THE READ-OUT, Ohms Zero).

PROCEDURE

| FUNCTION SWITCH POSITION | RANGE SWITCH POSITION | APPLY APPROXIMATELY | ADJUST | LOCATION (Figure No.) | READOUT TO DISPLAY OHMIC VALUE APPLIED, WITHIN |
|---|---|---|---|---|---|
| Ω | H | 1500 Ω | R2 | 4-2 | 0.1% RDG + 0.1% F.S. |
| Ω | M | 150 Ω | NONE | --- | 0.1% RDG + 0.1% F.S. |
| Ω | L | 15 Ω | NONE | --- | 0.1% RDG + 0.2% F.S. |
| KΩ | L | 15 KΩ | NONE | --- | 0.1% RDG + 0.1% F.S. |
| KΩ | M | 150 KΩ | NONE | --- | 0.1% RDG + 0.1% F.S. |
| KΩ | H | 1500 KΩ | R12 | 4-2 | 0.5% RDG + 0.1% F.S. |
| MEGΩ | L | 15 MEGΩ | R13 | 4-2 | 1% RDG + 0.2% F.S. |
| MEGΩ | M | 150 MEGΩ | NONE | --- | 20% RDG + 0.2% F.S. |
| MEGΩ | H | 1500 MEGΩ | NONE | --- | USEABLE FOR RELATIVE MEASUREMENTS |

Figure 4-5. Ohms Calibration




NOTES

1. INSTRUMENT MUST FIRST BE CALIBRATED IN VDC MODE.
2. ZERO READOUT IN VDC MODE (REFER TO CHAPTER II, ZEROING THE READOUT, MVDC OR VDC Zero).
3. PRIOR TO EACH RANGE OR FUNCTION CHANGE, ZERO THE READOUT IN VAC MODE (REFER TO CHAPTER II, ZEROING THE READOUT, VAC Zero).

PROCEDURE

| FUNCTION SWITCH POSITION | RANGE SWITCH POSITION | APPLY APPROXIMATELY | ADJUST | LOCATION (Figure No.) | READOUT TO DISPLAY VOLTAGE APPLIED, WITHIN |
|---|---|---|---|---|---|
| VAC | L | 15 VAC, 400 Hz<br>WARNING<br>HIGH VOLTAGE | R33 | 4-2 | 3% F.S. (0.5V & UP) |
| VAC | M | 150 VAC, 400 Hz | R35 | 4-2 | 3% F.S. |
| VAC | H | 250 VAC, 400 Hz | R37 | 4-2 | 3% F.S. |

CAUTION
DO NOT APPLY MORE THAN
300 VAC OR DAMAGE TO THE INSTRUMENT MAY RESULT

Figure 4-6. VAC Calibration

single phase power source (or 230 VAC option).

4. Turn ON DISPLAY control clockwise until an audible click is heard. Allow 30 minutes for instrument warm-up.

Procedure

1. To ensure proper line voltage, fuse operation and functioning power switch, measure the voltage across two of the three rear output connectors (labled Accessory Power Supply) for PS-1 operation. Value should be approximately 40 VAC.

   a. If value is not approximately 40 VAC, check line voltage, fuse (F1), power switch (S2) and transformer (T1).

   b. If value is approximately 40 VAC, proceed to step 2.

2. Check the following voltage supplies: (all to be within 5%):

   a. +5 VDC - Ripple - 50 MVAC p-p at pin 29 of J3 on Amplifier and Logic Assembly (Figure 5-6).

   b. +15 VDC - Ripple - 60 MVAC p-p at pin 21 of J3 on Amplifier and Logic Assembly (Figure 5-6).

   c. -15 VDC - Ripple - 80 MVAC p-p at pin 23 of J3 on Amplifier and Logic Assembly (Figure 5-6).

   d. +220 VDC - Ripple - 5 VAC p-p at pin 41 on R/O and Counter Assembly (Figure 5-4).

   e. -36 VDC - Ripple - 5 VAC p-p at pin 41 of J3 Amplifier and Logic Assembly (Figure 5-6).

   f. If the above voltages are not within tolerance check the associated supply/s.

   g. If the voltages are within tolerance, proceed to step 3.

3. Place function switch in MVDC position and range switch in H position. Short VDC input jack and measure zero volts at analog output connectors. Rotate DC and OHMS ZERO control from its extreme clockwise to counterwise positions; the analog output should vary approximately 12 millivolts. Apply plus one volt to VDC input, and measure plus three volts at the analog output connectors. Apply minus one volt to the VDC input and measure minus three volts at the analog output connectors.

   a. If any of the above three measurements are not as specified, replace input amplifier A1 on Amplifier and Logic Assembly (Figure 5-6).

   b. If the above measurements are as specified, proceed to step 4.

4. Apply minus one volt to VDC input with function switch in MVDC position and range switch in H position. Measure approximately minus 3.6 volts between TP8 (Figure 4-1) and ground.

   a. If the above condition does not exist, replace A2 (Polarity Amplifier) on Amplifier and Logic Assembly (Figure 5-6).

   b. If the above condition does exist, proceed to step 5.

5. Apply greater than two volts to VDC input with function switch in MVDC position and range switch in H position to cause the overload indicator (OL) to illuminate. Connect the junction of R26 and R19 on R/O and Counter Assembly (Figure 5-4) to a plus five-volt source. The readout should extinguish. If it does not, check blanking circuit.

   a. Set oscilloscope sensitivity controls

to 20 μSEC/CM and 2 V/CM and connect leads to TP6 and ground. Clock pulses should appear as shown in Figure 4-7. If there are no clock pulses, check associated clock generators circuitry.

b. Change oscilloscope leads to TP5 and ground. Clock pulses should appear as shown in Figure 4-7. If they do not exist, check transistor Q8 on Amplifier and Logic Assembly (Figure 5-6) for operation. If Q8 is operating, replace comparator amplifier A3 on Amplifier and Logic Assembly (Figure 5-6).

c. If clock pulses appear as shown in Figure 4-7, proceed to step 6.

6. With the same conditions as set forth in step 5, connect leads of oscilloscope to TP10 and ground. Clock pulses should appear as shown in Figure 4-7. If none exist, replace A4 on Amplifier and Logic Assembly (Figure 5-6).

a. If "up" clock pulses do exist, connect leads of oscilloscope to pin 14 of A4 on the R/O and Counter Assembly (Figure 5-4) and ground. If none exist, replace Q16 on the R/O and Counter Assembly.

b. If clock pulses, as shown in Figure 4-7, appear at pin 14 of A4, check for divide-by-ten clock pulses at pin 14 of A3 on R/O and Counter Assembly (Figure 5-4). If they do not exist, replace A4.

c. If divide-by-ten pulses exist at pin 14 of A3, check for divide-by-ten pulses at pin 14 of A2. If they do not exist, replace A3. Check for divide-by-ten pulses at pin 13 of A2, R/O and Counter Assembly. If they do not exist, replace A2.

d. If clock pulses exist in all of the above conditions, proceed to step 7.

7. Apply approximately one volt to VDC input with function switch in MVDC position and range switch in H position. If the readout displays an overload condition (OL) and down pulses do not appear on oscilloscope with leads connected to TP7 (Figure 4-1) and ground, replace A5 on Amplifier and Logic Assembly (Figure 5-6).

8. Check to see if the weighted 1-2-4-8 bridge resistors are "falling in" correctly as each of the decade counters A2, A3 and A4 continuously count. Produce an overload condition and blank the readout as outlined in step 5.

a. With the sensitivity controls set to 100 μSEC/CM and 0.5 V/CM connect the leads of oscilloscope to the junction of

Figure 4-7. Clock Pulses

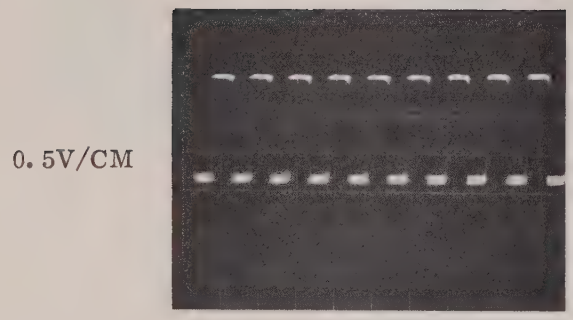



Figure 4-8. Decade "One Bit"

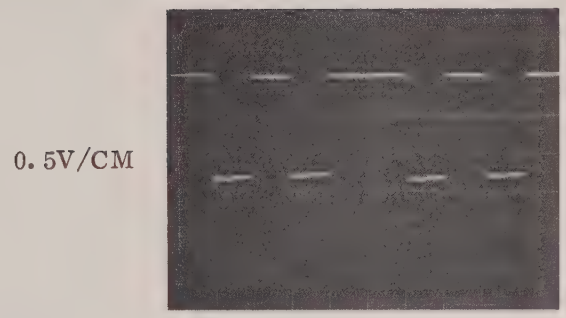



Figure 4-9. Decade "Two Bit"

CR38 and R48 (Figure 5-7). The pattern displayed on oscilloscope should be as shown in Figure 4-8.

b. Change the oscilloscope leads to the junction of CR36 and R47 (Figure 5-7). The pattern displayed on oscilloscope should be as shown in Figure 4-9.

c. If the above conditions do not exist, check the associated bridge resistors and diodes.

## CHAPTER V

## PARTS LIST

This Chapter provides a list of electrical and electronic parts for the Series X-3 Digital Voltmeter. The parts are callout on photographs and are listed by circuit reference.

Manufacturers of all components called out in the parts lists are referred to by their Manufacturer's five-digit code number. Manufacturers and their codes are as follows:

| Code | Manufacturer |
|---|---|
| 00327 | Welwyn International, Inc.<br>Cleveland, Ohio |
| 01121 | Allen Bradly Company<br>1201 South Second Street<br>Milwalkee, WI |
| 01295 | Texas Instruments, Inc.<br>Transistor Products Division<br>Dallas, TX |
| 03607 | Radio Corp. of America Commercial<br>Electronic Products Division<br>Los Angeles, CA |
| 03626 | Non-Linear Systems, Inc.<br>P.O. Box N<br>Del Mar, CA |
| 04713 | Motorola, Inc.<br>Semiconductor Products Division<br>5005 East McDowell Road<br>Phoenix, AZ |
| 07263 | Fairchild Camera & Instrument Corp.<br>Semiconductor Division<br>313 Bayshore Frontage Road<br>Mountain View, CA |
| 07436 | Components, Inc.<br>Van Nuys, CA |
| 07793 | Cornell-Dubilier Electronics<br>Division<br>Federal Pacific Electric Corp.<br>4144 Glencoe Avenue<br>Venice, CA |
| 14752 | Electro Cube, Inc.<br>805 Fairway<br>South Pasadena, CA |

| Code | Manufacturer |
|---|---|
| 15605 | Cutler-Hammer, Inc.<br>Milwaukee, IL |
| 71590 | Centralab Division of Globe-<br>Union, Inc.<br>932 East Keife Avenue<br>Milwaukee, WI |
| 73138 | Helipot Division of Beckman<br>Instruments, Inc.<br>2500 Harbor Boulevard<br>Fullerton, CA |
| 73445 | Amperex Electronics Co.<br>Division of North American<br>Philips Co., Inc. |
| 75915 | Littlefuse, Inc.<br>800 East Northwest Highway<br>Des Plaines, IL |
| 77764 | Resistance Products Co.<br>914 South 13th St.<br>Harrisburg, PA |
| 80183 | Sprague Products<br>North Adams, MA |
| 81483 | International Rectifier Corp.<br>1523 East Grand Ave.<br>El Segundo, CA |
| 83330 | Smith Herman H., Inc.<br>2334 Nostrand Avenue<br>Brooklyn, NY |
| 91418 | Radio Materials Co.<br>2442 West Bryon Mawr.<br>Chicago, IL |
| 91662 | Elco Corp.<br>Philadelphia, PA |

| | | |
|---|---|---|
| 99142 | General Electric Co.<br>Industrial Electronics Division<br>of Electronic Atomic and Defense<br>Systems Group<br>Utica, NY | |

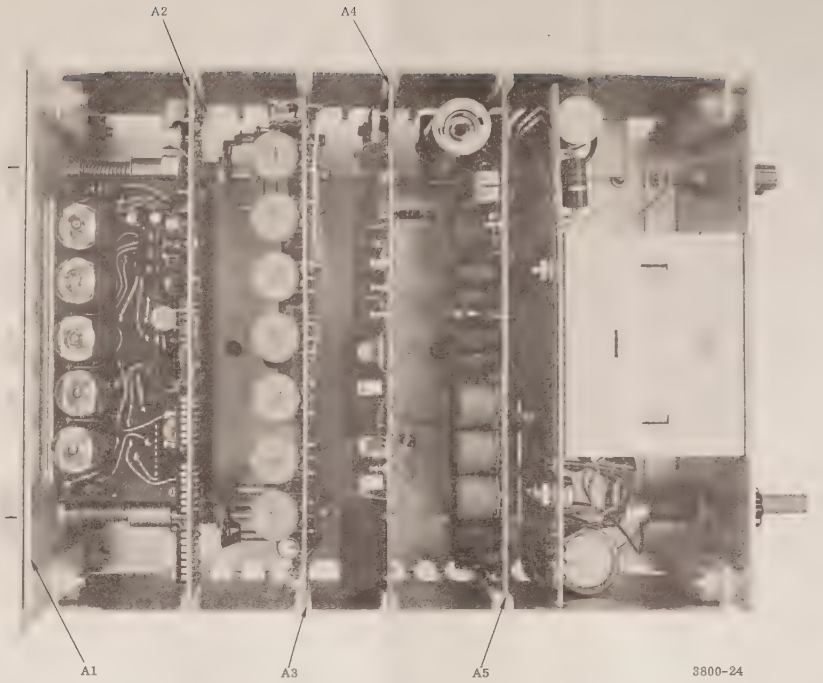



Figure 5-1. DVM Final Assembly

| CIRCUIT REFERENCE | PART NO. | DESCRIPTION | QTY PER ASSY. | MANUFACTURER'S CODE |
|---|---|---|---|---|
| A1 | 38-128 | DVM ASSEMBLY | 1 | 03626 |
| A2 | 38-115 | R/O & COUNTER ASSEMBLY | 1 | 03626 |
| A3 | 38-98 | ATTENUATOR ASSEMBLY | 1 | 03626 |
| A4 | 38-113 | AMPLIFIER & LOGIC ASSEMBLY | 1 | 03626 |
| A5 | 38-107 | D/A CONVERTER & REFERENCE ASSEMBLY | 1 | 03626 |

Figure 5-2. DVM Assembly, Main Board and Power Supply

| CIRCUIT REFERENCE | PART NO. | DESCRIPTION | QTY PER ASSY. | MANUFACTURER'S CODE |
|---|---|---|---|---|
| 1 | 38-135 | POWER SUPPLY BOARD ASSEMBLY | 1 | 03626 |
| F1 | 313.375 | FUSE, 3AG 3/8A, SLO-BLO | 1 | 75914 |
| J5 | 277 | PHONE JACK | 1 | 83330 |
| R1/S2 | 38-136 | POTENTIOMETER/SWITCH, 350K | 1 | 03626 |
| R2 | 38-137 | POTENTIOMETER, 350K, ±20% | 1 | 03626 |
| R3 | 38-138 | POTENTIOMETER, 350K, ±20% | 1 | 03626 |
| R4 | RC07GF754J | RESISTOR, 750K, 1/4W, 5% | 1 | 01121 |
| R5 | RC20GF364J | RESISTOR, 360K, 1/2W, 5% | 1 | 01121 |
| S1 | 8280K21F | SWITCH, TOGGLE | 1 | 15605 |
| T1 | D-261 | TRANSFORMER | 1 | 03626 |

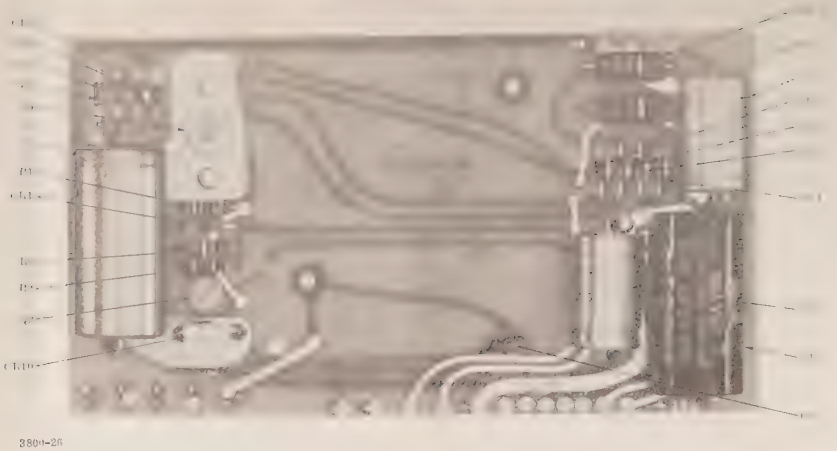
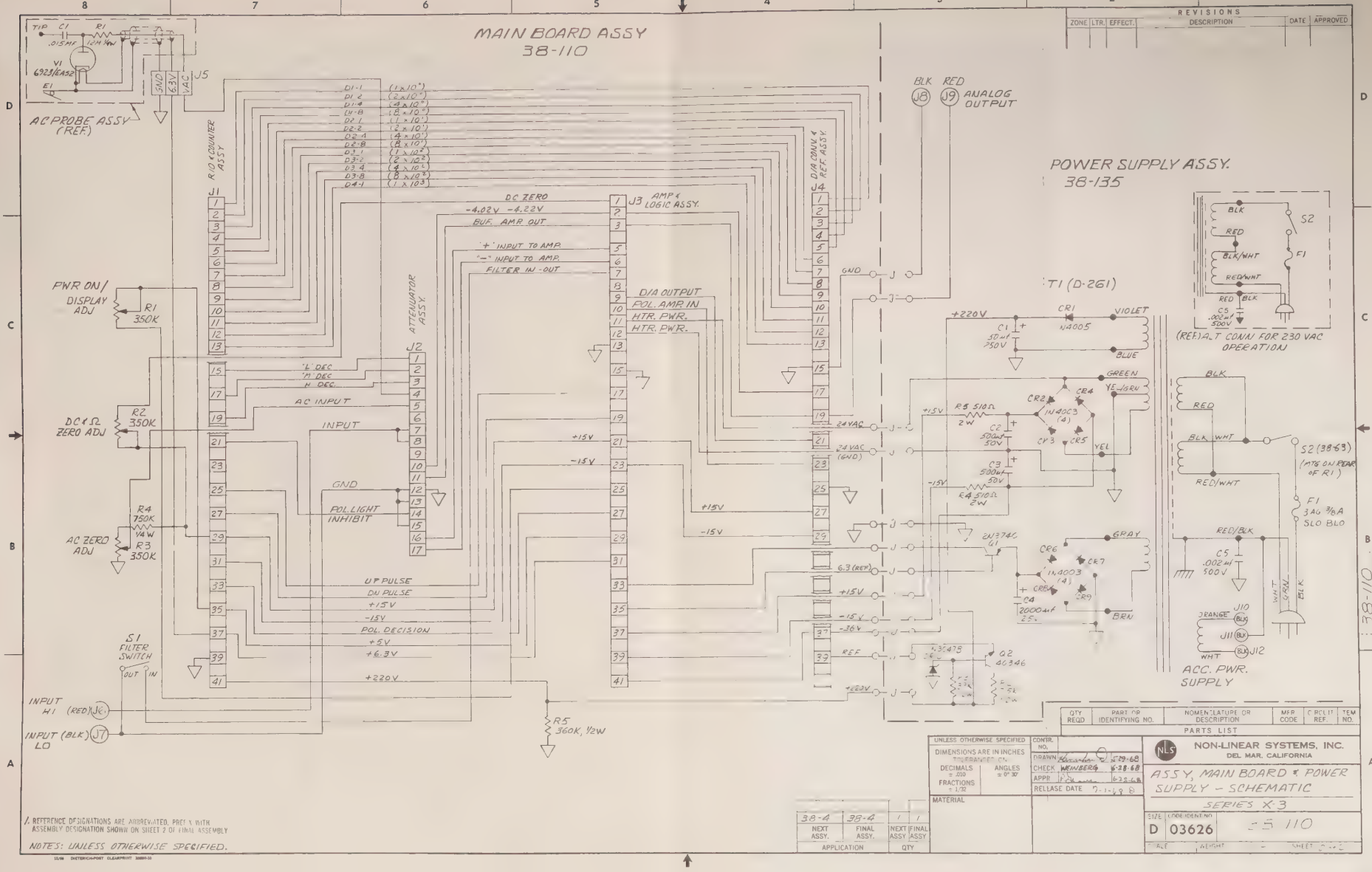
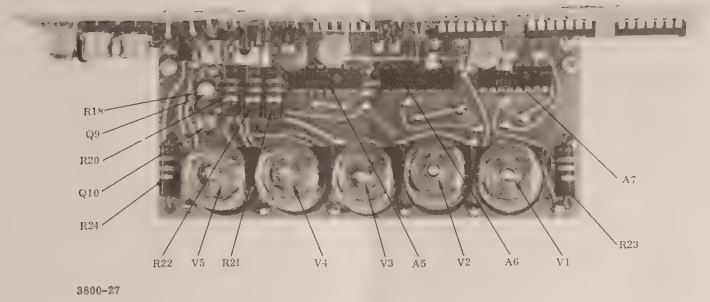



Figure 5-3. Power Supply Board Assembly

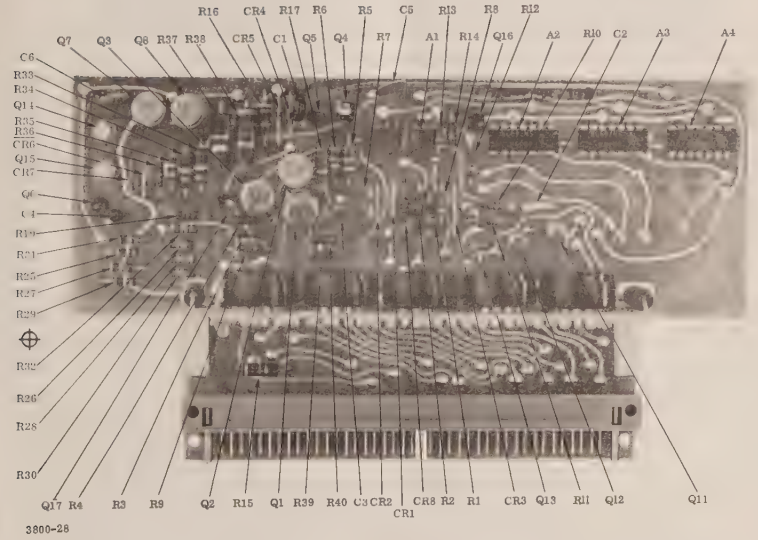
| CIRCUIT REFERENCE | PART NO. | DESCRIPTION | QTY PER ASSY. | MANUFACTURER'S CODE |
|---|---|---|---|---|
| C1 | BR50-250 | CAPACITOR, 50μF, 250V | 1 | 07793 |
| C2 & C3 | 2222-023-90011 | CAPACITOR, 500μF, 50V | 2 | 73445 |
| C4 | 2222-063-90042 | CAPACITOR, 2000μF, 25V | 1 | 73445 |
| C5 | 5002-010 | CAPACITOR, 0.002μF, 500V | 1 | 03626 |
| CR1 | 1N4005 | DIODE | 1 | 04713 |
| CR2 thru CR9 | 1N4003 | DIODE | 8 | 04713 |
| CR10 | 1N3047B | DIODE | 1 | 02195 |
| Q1 | 2N3740/2N3741* | TRANSISTOR | 1 | 01295 |
| Q2 | 40346 | TRANSISTOR | 1 | 03607 |
| R1 | RC20GF431J | RESISTOR, 430Ω, 1/2W, 5% | 1 | 01121 |
| R2 | RC20GF752J | RESISTOR, 7.5K, 1/2W, 5% | 1 | 01121 |
| R3 | RC20GF393J | RESISTOR, 39K, 1/2W, 5% | 1 | 01121 |
| R4 & R5 | RC20GF511J | RESISTOR, 510Ω, 2W, 5% | 2 | 01121 |

*Alternate


MAIN BOARD ASSY
38-110
REVISIONS
ZONE | LTR. | EFFECT. | DESCRIPTION | DATE | APPROVED
AC PROBE ASSY (REF.)
V1 6923/EA52
C1 .015MF
R1 12M 1W
E1
J5
GND
63V
VAC
R.D. COUNTER ASSY.
D/A CONV'R REF. ASSY.
J1
J4
J3 AMP & LOGIC ASSY.
J2 ATTENUATOR ASSY.
DC ZERO
-4.02V -4.22V
BUF. AMP. OUT
+ INPUT TO AMP.
- INPUT TO AMP.
FILTER IN -OUT
D/A OUTPUT
POL. AMP. IN
HTR. PWR.
HTR. PWR.
BLK J8
RED J9
ANALOG OUTPUT
POWER SUPPLY ASSY.
38-135
T1 (D-261)
PWR ON/ DISPLAY ADJ
R1 350K
DC Ω ZERO ADJ
R2 350K
AC ZERO ADJ
R4 750K 1/4 W
R3 350K
'L' DEC
'M' DEC
'N' DEC
AC INPUT
INPUT
GND
POL LIGHT INHIBIT
UP PULSE
DN PULSE
+15V
-15V
POL. DECISION
+5V
+6.3V
+220V
24 VAC
24 VAC (GND)
6.3 (REF)
REF
+250V
S1 FILTER SWITCH
OUT IN
INPUT HI (RED) J6
INPUT (BLK) LO J7
R5 360K, 1/2W
+220V
CR1 IN4005
VIOLET
BLUE
C1 50 uf 250V
CR2 CR4 CR3 CR5 IN4003 (4)
GREEN
YEL/GRN
YEL
R5 510Ω 2W
C2 500uf 50V
C3 500uf 50V
R4 510Ω 2W
2N3740
CR6 CR7 CR8 CR9 IN4003 (4)
GRAY
BRN
C4 2000uf 25V
2N3478
Q2 40346
S2
BLK
RED
BLK/WHT
RED/WHT
F1
C5 .002uf 700V
(REF) ALT CONN FOR 230 VAC OPERATION
S2 (38-53) (MTG ON REAR OF R1)
F1 3AG 3/8A SLO BLO
RED/BLK
C5 .002uf 500V
ORANGE
J10
J11
J12
ACC. PWR. SUPPLY
38-110 SW2
1/ REFERENCE DESIGNATIONS ARE ABBREVIATED. PREFIX WITH ASSEMBLY DESIGNATION SHOWN ON SHEET 2 OF FINAL ASSEMBLY
NOTES: UNLESS OTHERWISE SPECIFIED.
QTY REQD | PART OR IDENTIFYING NO. | NOMENCLATURE OR DESCRIPTION | MFR CODE | CIRCUIT REF. | ITEM NO.
PARTS LIST
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS ± .010
FRACTIONS ± 1/32
ANGLES ± 0° 30'
CONTR. NO.
DRAWN 6-29-68
CHECK MEMBERS 6-28-68
APPR 6-28-68
RELEASE DATE 7-1-68
MATERIAL
38-4 NEXT ASSY. | 38-4 FINAL ASSY. | NEXT ASSY | FINAL ASSY
APPLICATION | QTY
NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA
ASSY, MAIN BOARD & POWER SUPPLY - SCHEMATIC
SERIES X-3
SIZE D | CODE IDENT NO. 03626 | 38-110
SCALE | WEIGHT | SHEET




Readout Board



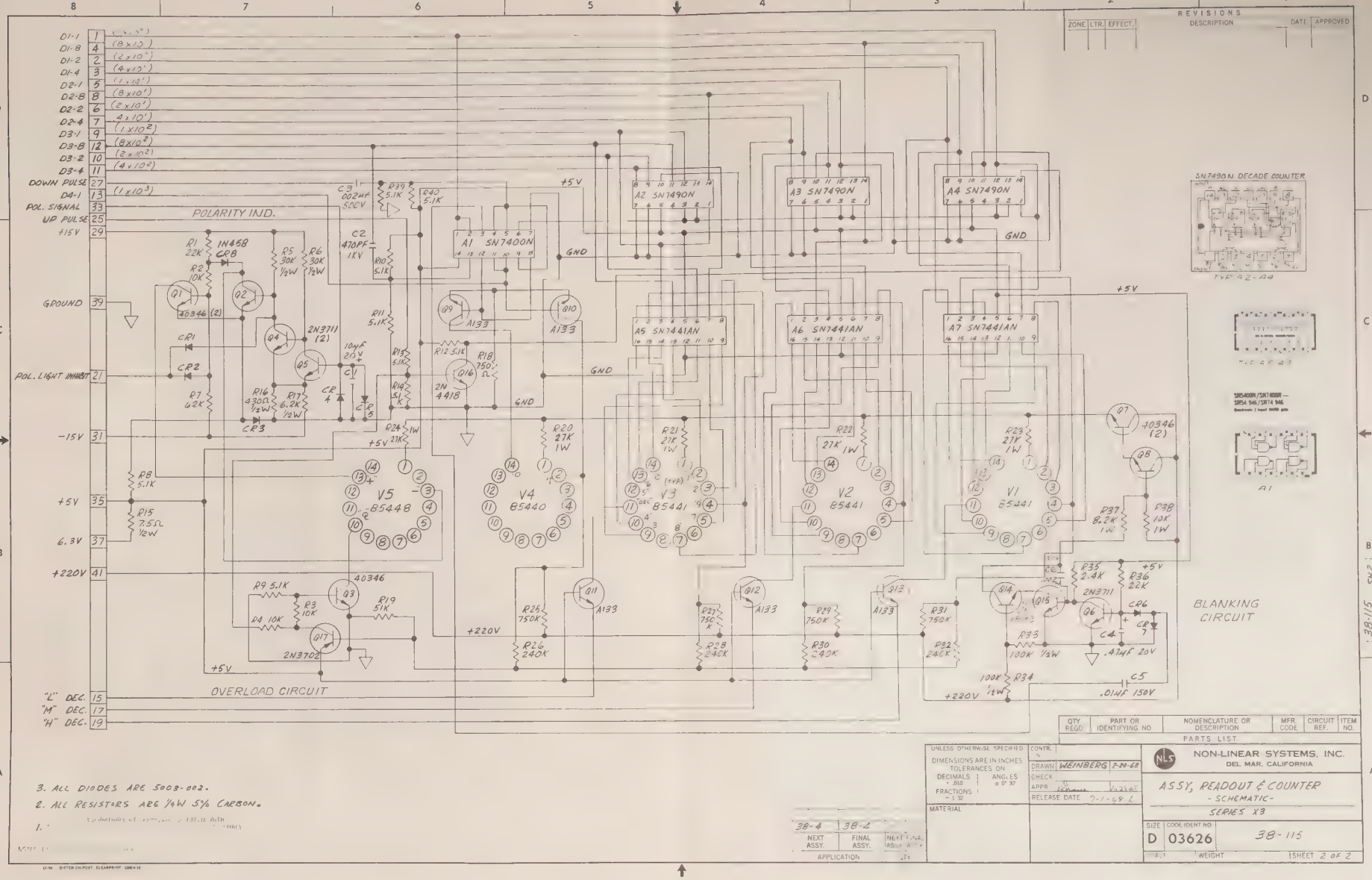

Counter Board

Figure 5-4. Readout and Counter Assembly

R/O and Counter Assembly, P/N 38-115

| CIRCUIT REFERENCE | PART NO. | DESCRIPTION | QTY PER ASSY. | MANUFACTURER'S CODE |
|---|---|---|---|---|
| A1 | SN7400N | DIP, Quad Input Gate | 1 | 01295 |
| A2 thru A4 | SN7490N | DIP, Decade Counter | 3 | 01295 |
| A5 thru A7 | SN7441AN | DIP, Decode Driver | 3 | 01295 |
| C1 | TSD2-20-106 | CAPACITOR, 10μF, 20V | 1 | 07436 |
| C2 | JL470 | CAPACITOR, 470 PF, 1KV | 1 | 91418 |
| C3 & C6 | 5002-010 | CAPACITOR, 0.002μF, 500V | 2 | 03626 |
| C4 | TSD1-20-474 | CAPACITOR, 0.47μF, 20V | 1 | 07436 |
| C5 | DDM103/BT101* | CAPACITOR, 0.01μF, 15V | 1 | 71590 |
| CR1 thru CR7 | 5003-002 | DIODE | 7 | 03626 |
| CR8 | IN458 | DIODE | 1 | 04713 |
| Q1 thru Q3, Q7 & Q8 | 40346 | TRANSISTOR | 5 | 03607 |
| Q4 thru Q6 | 2N3711 | TRANSISTOR | 3 | 01295 |
| Q9 & Q10 | A133/2N720A* | TRANSISTOR | 2 | 73445 |
| Q11 thru Q13 | A133/2N720A*/ 2N1893* | TRANSISTOR | 3 | 04713 |
| Q14 & Q15 | 2N1893/2N720A* | TRANSISTOR | 2 | 04713 |
| Q16 | 2N4418 | TRANSISTOR | 1 | 01295 |
| Q17 | 2N3702 | TRANSISTOR | 1 | 61295 |
| R1 & R36 | RC07GF223J | RESISTOR, 22K, 1/4W, 5% | 2 | 01121 |
| R2 thru R4 | RC07GF103J | RESISTOR, 10K, 1/4W, 5% | 3 | 01121 |
| R5 & R6 | RC20GF303J | RESISTOR, 30K, 1/2W, 5% | 2 | 01121 |
| R7 | RC07GF623J | RESISTOR, 62K, 1/4W, 5% | 1 | 01121 |
| R8 thru R14, R39 & R40 | RC07GF512J | RESISTOR, 5.1K, 1/4W, 5% | 9 | 01121 |
| R15 | RC20GF7R5J | RESISTOR, 7.5Ω, 1/2W, 5% | 1 | 01121 |
| R16 | RC20GF[illegible] | RESISTOR, 43Ω, 1/2W, 5% | 1 | 01121 |
| R17 | RC20GF[illegible] | RESISTOR, 6.2K, 1/2W, 5% | 1 | 01121 |
| R18 | RC07GF[illegible] | RESISTOR, 750Ω, 1/4W, 5% | 1 | 01121 |
| R19 | RC07GF[illegible] | RESISTOR, 51K, 1/4W, 5% | 1 | 01121 |
| R20 thru R24 | RC42GF[illegible] | RESISTOR, 27K, 1W, 5% | 5 | 01121 |
| R25, R27, R29 & R31 | RC07GF754J | RESISTOR, 750K, 1/4W, 5% | 4 | 01121 |
| R26, R28, R30 & R32 | RC07GF244J | RESISTOR, 240K, 1/4W, 5% | 4 | 01121 |
| R33 & R34 | RC20GF104J | RESISTOR, 100K, 1/2W, 5% | 2 | 01121 |
| R35 | RC07GF242J | RESISTOR, 2.4K, 1/4W, 5% | 1 | 01121 |
| R37 | RC32GF882J | RESISTOR, 8.2K, 1W, 5% | 1 | 01121 |
| R38 | RC32GF103J | RESISTOR, 10K, 1W, 5% | 1 | 01121 |
| V1 thru V3 | B5441 | INDICATOR TUBE (0 thru 9 & Decimal) | 3 | 83594 |
| V4 | B5440 | INDICATOR TUBE (0 and 1) | 1 | 83594 |
| V5 | B5448 | INDICATOR TUBE (Polarity & Ω) | 1 | 83594 |

*Alternate


REVISIONS
ZONE | LTR. | EFFECT. | DESCRIPTION | DATE | APPROVED
POLARITY IND.
OVERLOAD CIRCUIT
BLANKING CIRCUIT
A1 SN7400N
A2 SN7490N
A3 SN7490N
A4 SN7490N
A5 SN7441AN
A6 SN7441AN
A7 SN7441AN
V1 B5441
V2 B5441
V3 B5441
V4 B5440
V5 B5448
SN7490N DECADE COUNTER
TYP A2 - A4
A1
DI-1
DI-8
DI-2
DI-4
D2-1
D2-8
D2-2
D2-4
D3-1
D3-8
D3-2
D3-4
DOWN PULSE
D4-1
POL. SIGNAL
UP PULSE
+15V
GROUND
POL. LIGHT INHIBIT
-15V
+5V
6.3V
+220V
"L" DEC.
"M" DEC.
"H" DEC.
+5V
GND
+220V
2N3711
2N3702
2N 4418
A133
40346
IN458 CRB
.002uf 500V
470PF 1KV
.1uf 20V
.01uf 150V
.47uf 20V
7.55Ω ½W
6.2K ½W
430Ω ½W
8.2K 1W
10K 1W
100K ½W
2.4K
22K
240K
750K
27K 1W
51K
10K
7.5K
62K
10uf 20V
3. ALL DIODES ARE 5003-002.
2. ALL RESISTORS ARE ¼W 5% CARBON.
1.
PARTS LIST
QTY REQD | PART OR IDENTIFYING NO | NOMENCLATURE OR DESCRIPTION | MFR. CODE | CIRCUIT REF. | ITEM NO.
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS | ANGLES
FRACTIONS
CONTR.
DRAWN WEINBERG 2-20-68
CHECK
APPR
RELEASE DATE 7-1-68
MATERIAL
NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA
ASSY, READOUT & COUNTER
- SCHEMATIC -
SERIES X3
SIZE D
CODE IDENT NO 03626
38-115
SHEET 2 OF 2
38-4
NEXT ASSY.
38-2
FINAL ASSY.
APPLICATION
38-115 SH2

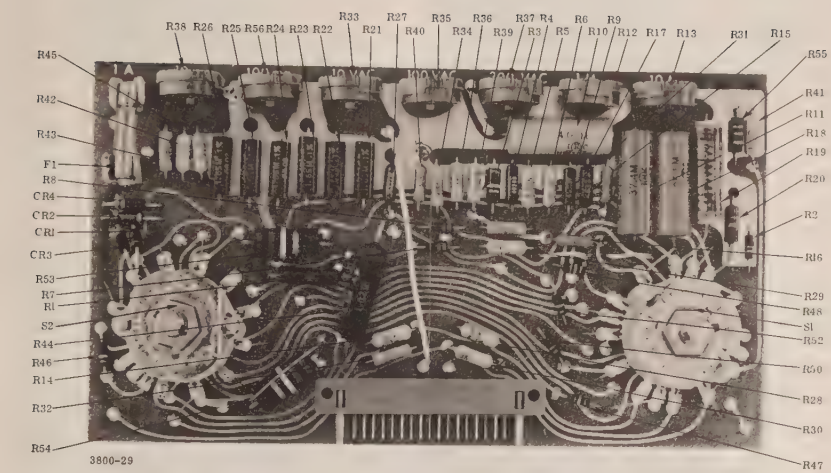
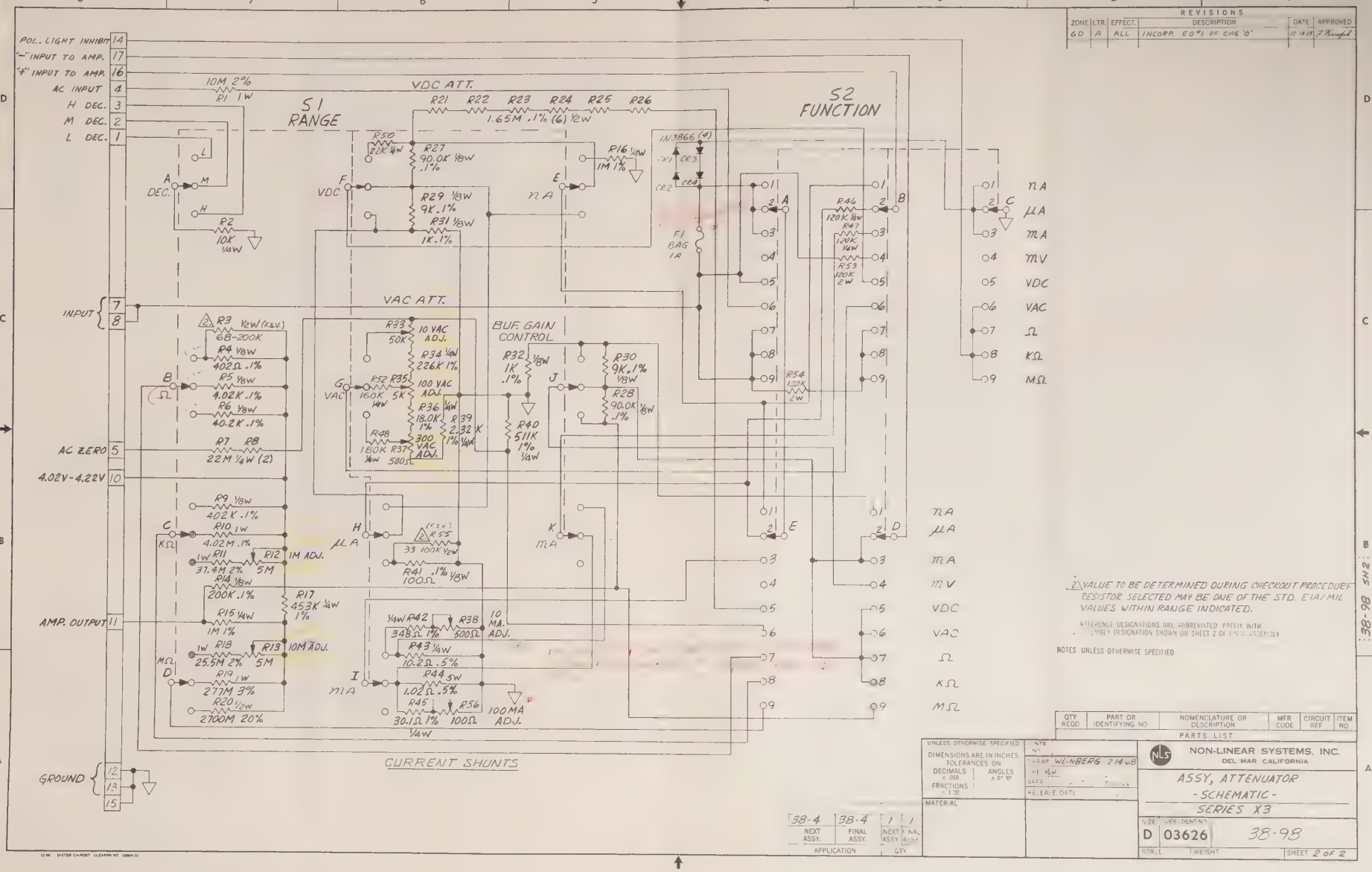



Figure 5-5. Attenuator Assembly

Attenuator Assembly, P/N 38-98

| CIRCUIT REFERENCE | PART NO. | DESCRIPTION | QTY PER ASSY. | MANUFACTURER'S CODE |
|---|---|---|---|---|
| CR1 thru CR4 | IN3866 | DIODE | 4 | 04713 |
| F1 | 361001 | FUSE 3AG 1A | 1 | 75915 |
| R1 | RN75B1005G | RESISTOR, 10 Meg, 1W, 2% | 1 | 01121 |
| R2 | RC07GF103J | RESISTOR, 10K, 1/4W, 5% | 1 | 01121 |
| R3 | RC20GF | RESISTOR, 68K-200K, 1/2W, 5% (Factory Selected Value) | 1 | 01121 |
| R4 | RN60C4020B | RESISTOR, 402Ω, 1/8W, 0.1% | 1 | 01121 |
| R5 | RN60C4021B | RESISTOR, 4.02K, 1/8W, 0.1% | 1 | 01121 |
| R6 | RN60C4022B | RESISTOR, 40.2K, 1/8W, 0.1% | 1 | 01121 |
| R7 & R8 | RC07GF226J | RESISTOR, 22 Meg, 1/4W, 5% | 2 | 01121 |
| R9 | RN60C4023B | RESISTOR, 402K, 1/8W, 0.1% | 1 | 01121 |
| R10 | RN75C4024B | RESISTOR, 4.02 Meg, 1W, 0.1% | 1 | 01121 |
| R11 | M13/RN75B3745G* | RESISTOR, 37.4 Meg, 1W, 2% | 1 | 00327 |
| R12 & R13 | MOD. 9 - 5M | POTENTIOMETER, 5 Meg | 2 | 71590 |
| R14 | RN60C2003B | RESISTOR, 200K, 1/4W, 0.1% | 1 | 01121 |
| R15 & R16 | RN60D1004F | RESISTOR, 1 Meg, 1/4W, 0.1% | 2 | 01121 |
| R17 | RN60D4533F | RESISTOR, 453K, 1/4W, 0.1% | 2 | 01121 |
| R18 | RN75B2555G | RESISTOR, 25.5 Meg, 1W, 2% | 1 | 01121 |
| R19 | BBFW277 | RESISTOR, 277 Meg, 1W, 3% | 1 | 77764 |
| R20 | RC20GF278M/ GBT 1/2* | RESISTOR, 2700 Meg, 1/2W, 20% | 1 | 01121 |
| R21 thru R26 | RN70C1654B | RESISTOR, 1.65 Meg, 1/2W, 0.1% | 6 | 01121 |
| R27 & R28 | RN60C9002B | RESISTOR, 90.0K, 1/8W, 0.1% | 2 | 01121 |
| R29 & R30 | RN60C9001B | RESISTOR, 9K, 1/8W, 0.1% | 2 | 01121 |
| R31 & R32 | RN60C1001B | RESISTOR, 1K, 1/8W, 0.1% | 2 | 01121 |
| R33 | MOD. 9-50K | POTENTIOMETER, 50K | 1 | 71590 |
| R34 | RN60D2263F | RESISTOR, 226K, 1/4W, 0.1% | 1 | 01121 |
| R35 | MOD. 9-5K | POTENTIOMETER, 5K | 1 | 71590 |
| R36 | RN60D1802F/ GP 1/2 * | RESISTOR, 18.0K, 1/4W, 0.1% | 1 | 01121 |
| R37 & R38 | MOD. 9-500Ω | POTENTIOMETER, 500Ω | 2 | 71590 |
| R39 | RN60D2321F | RESISTOR, 2.32K, 1/4W, 0.1% | 1 | 01121 |
| R40 | RN60D5113F | RESISTOR, 511K, 1/4W, 0.1% | 1 | 01121 |
| R41 | RN60C1000B | RESISTOR, 100Ω, 1/8W, 0.1% | 1 | 01121 |
| R42 | RN60D3480F | RESISTOR, 348Ω, 1/4W, 0.1% | 1 | 01121 |
| R43 | RN60D10R2D | RESISTOR, 10.2Ω, 1/4W, 0.5% | 1 | 01121 |
| R44 | RW67VIR02D | RESISTOR, 1.02Ω, 5W, 0.5% | 1 | 01121 |
| R45 | RN60D30RIF | RESISTOR, 30.1Ω, 1/4W, 0.1% | 1 | 01121 |
| R46 & R47 | RC07GF124J | RESISTOR, 120K, 1/4W, 5% | 2 | 01121 |
| R48 | RC07GF194J | RESISTOR, 180K, 1/4W, 5% | 1 | 01121 |
| R50 | RC07GF223J | RESISTOR, 22K, 1/4W, 5% | 1 | 01121 |
| R52 | RC07GF164J | RESISTOR, 160K, 1/4W, 5% | 1 | 01121 |
| R53 & R54 | RC42GF124J | RESISTOR, 120K, 2W, 5% | 2 | 01121 |
| R55 | RC20GF | RESISTOR, 33K, 100K, 1/2W, 5% | 1 | 01121 |
| R56 | MOD. 9-100Ω | POTENTIOMETER, 100Ω | 1 | 71590 |
| S1 | 38-78 | SWITCH, RANGE | 1 | 03626 |
| S2 | 38-79 | SWITCH, FUNCTION | 1 | 03626 |

*Alternate




2 VALUE TO BE DETERMINED DURING CHECKOUT PROCEDURE. RESISTOR SELECTED MAY BE ONE OF THE STD. EIA/MIL VALUES WITHIN RANGE INDICATED.

REFERENCE DESIGNATIONS ARE ABBREVIATED PREFIX WITH ASSEMBLY DESIGNATION SHOWN ON SHEET 2 OF THIS ASSEMBLY

NOTES UNLESS OTHERWISE SPECIFIED

| REVISIONS | | | | | |
|---|---|---|---|---|---|
| ZONE | LTR. | EFFECT. | DESCRIPTION | DATE | APPROVED |
| GD | A | ALL | INCORP. EO #1 OF CHG 'O' | 10-14-68 | J Bruff |

PARTS LIST

| QTY REQD | PART OR IDENTIFYING NO | NOMENCLATURE OR DESCRIPTION | MFR CODE | CIRCUIT REF | ITEM NO |
|---|---|---|---|---|---|

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS ± .010
ANGLES ± 0° 30'
FRACTIONS ± 1/32

NTR NO
DRAWN WEINBERG 2-14-68
CHK
APPD
RELEASE DATE

MATERIAL

NON-LINEAR SYSTEMS, INC.
DEL MAR CALIFORNIA

ASSY, ATTENUATOR
- SCHEMATIC -
SERIES X3

SIZE D | CODE IDENT NO 03626 | 38-98

SCALE | WEIGHT | SHEET 2 OF 2

| 38-4 | 38-4 | / | / |
|---|---|---|---|
| NEXT ASSY. | FINAL ASSY. | NEXT ASSY | N.A. ASSY |
| APPLICATION | | QTY | |

38-98 SH 2

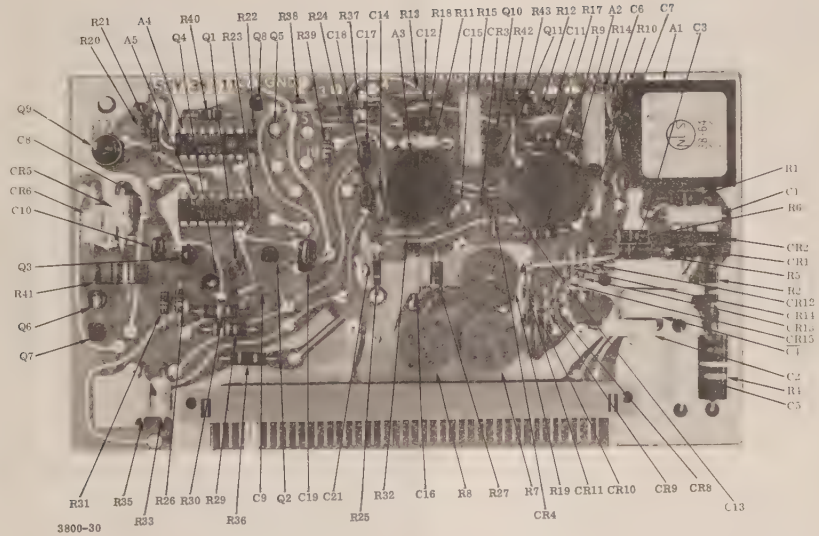


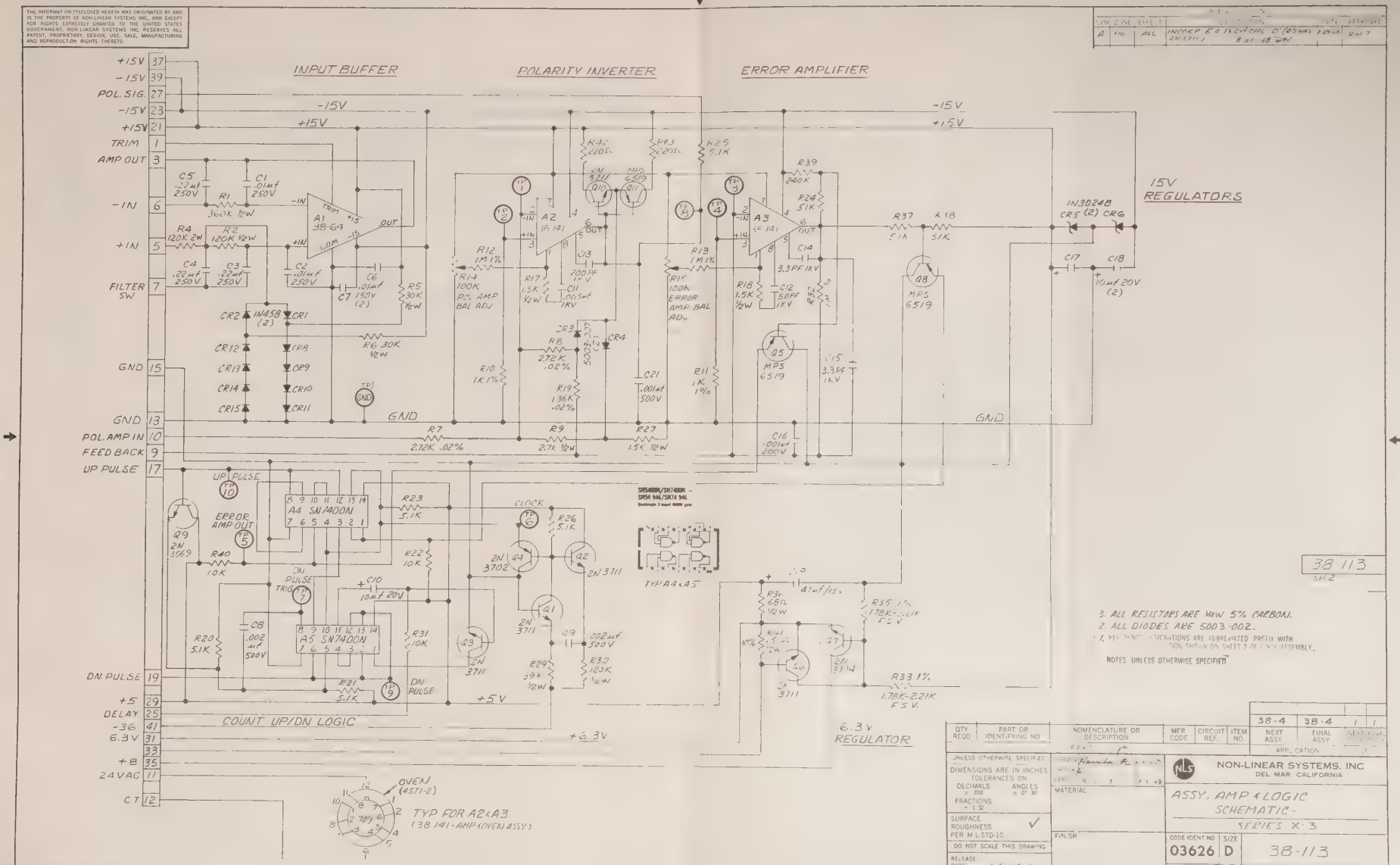

Figure 5-6. Amplifier and Logic Assembly

Amplifier and Logic Assembly, P/N 38-113

| CIRCUIT REFERENCE | PART NO. | DESCRIPTION | QTY PER ASSY. | MANUFACTURER'S CODE |
|---|---|---|---|---|
| A1 | 38-64 | AMPLIFIER | 1 | 03626 |
| A2 & A3 | 38-141 | AMPLIFIER & OVEN ASSEMBLY | 2 | 03626 |
| A4 & A5 | SN7400N | DIP, Quad 2 Input Gate | 2 | 01295 |
| C1 & C2 | C281AB/A10K | CAPACITOR, 0.01μF, 250V | 2 | 73445 |
| C3, C4 & C5 | C281AB/A220K | CAPACITOR, 0.22μF, 250V | 3 | 73445 |
| C6 & C7 | DDM103 | CAPACITOR, 0.01μF, 150V | 2 | 71590 |
| C8 & C9 | 5002-010 | CAPACITOR, 0.002μF, 500V | 2 | 03626 |
| C10, C17 & C18 | TSD2-20-106 | CAPACITOR, 10μF, 20V | 3 | 07436 |
| C11 | BT005 | CAPACITOR, 0.005μF, 100V | 1 | 91418 |
| C12 | DD500 | CAPACITOR, 50PF, 1KV | 1 | 71590 |
| C13 | DD201 | CAPACITOR, 200PF, 1KV | 1 | 71590 |
| C14 & C15 | DD3R3 | CAPACITOR, 3.3PF, 1KV | 2 | 71590 |
| C16 | 210B1C102 | CAPACITOR, 0.001μF, 200V | 1 | 14752 |
| C19 | TSD4-15-476 | CAPACITOR, 47μF, 15V | 1 | 07436 |
| C21 | 5002-011 | CAPACITOR, 0.001μF, 500V | 1 | 03626 |
| CR1 & CR2 | IN458 | DIODE | 2 | 04713 |
| CR3 & CR4 | 5003-007/5325* | DIODE | 2 | 03626 |
| CR5 & CR6 | IN3024B | DIODE, ZENER | 2 | 01295 |
| CR8 thru CR15 | 5003-002 | DIODE | 8 | 03626 |
| Q1 thru Q3, Q6 & Q10 | 2N3711 | TRANSISTOR | 5 | 02195 |
| Q4 | 2N3702 | TRANSISTOR | 1 | 2N3702 |
| Q5, Q8 & Q11 | MPS6519 | TRANSISTOR | 3 | 04713 |
| Q7 | 2N3704 | TRANSISTOR | 1 | 02195 |
| Q9 | 2N3569/2N3643* | TRANSISTOR | 1 | 07263 |
| R1 | RC20GF364J | RESISTOR, 360K, 1/2W, 5% | 1 | 01121 |
| R2 & R30 | RC20GF124J | RESISTOR, 120K, 1/2W, 5% | 2 | 01121 |
| R4 | RC42GF124J | RESISTOR, 120K, 2W, 5% | 1 | 01121 |
| R5 & R6 | RC20GF303J | RESISTOR, 30K, 1/2W, 5% | 2 | 01121 |
| R7 & R8 | PW2016C-27200H | RESISTOR, 2.72K, 0.02 | 2 | 03626 |
| R9 | RC20GF272J | RESISTOR, 2.7K, 1/2W, 5% | 1 | 01121 |
| R10 & R11 | RN60D1001F | RESISTOR, 1K, 1/4W, 0.1% | 2 | 01121 |
| R12, R13 & R32 | RN60D1004F | RESISTOR, 1 Meg, 1/4W, 0.1% | 2 | 01121 |
| R14 & R15 | 76P-R100K | POTENTIOMETER, 100K | 2 | 73138 |
| R17, R18 & R27 | RC20GF152J | RESISTOR, 1.5K, 1/2W, 5% | 3 | 01121 |
| R19 | PW2016C-13600H | RESISTOR, 1.36K, 0.02% | 1 | 03626 |
| R20, R21, R23 thru R26 & R37 | RC07GF512J | RESISTOR, 5.1K, 1/4W, 5% | 7 | 01121 |
| R22, R31 & R40 | RC07GF103J | RESISTOR, 10K, 1/4W, 5% | 3 | 01121 |
| R29 | RC20GF393J | RESISTOR, 39K, 1/2W, 5% | 1 | 01121 |
| R33 & R35 | RN60D/GP1/2* | RESISTOR, 1.78K, 2K, 2.1K, 2.21K, 1/4W, 0.1% (Factory Selected Values) | 2 | 01121 |
| R36 | RC20GF680J | RESISTOR, 68Ω, 1/2W, 5% | 1 | 01121 |
| R38 | RC07GF513J | RESISTOR, 51K, 1/4W, 5% | 1 | 01121 |
| R39 | RC07GF244J | RESISTOR, 240K, 1/4W, 5% | 1 | 01121 |
| R41 | BW20/BWH* | RESISTOR, 0.51Ω, 1/2W, 10% | 1 | |
| R42 & R43 | RC07GF221J | RESISTOR, 220Ω, 1/4W, 5% | 2 | 01121 |

*Alternate

THE INFORMATION DISCLOSED HEREIN WAS ORIGINATED BY AND IS THE PROPERTY OF NON-LINEAR SYSTEMS INC. AND EXCEPT FOR RIGHTS EXPRESSLY GRANTED TO THE UNITED STATES GOVERNMENT, NON-LINEAR SYSTEMS INC. RESERVES ALL PATENT, PROPRIETARY, DESIGN, USE, SALE, MANUFACTURING AND REPRODUCTION RIGHTS THERETO.




38 113
SHT 2

3. ALL RESISTORS ARE YAW 5% CARBON.
2. ALL DIODES ARE 5003-002.
1. REFERENCE DESIGNATIONS ARE ABBREVIATED PREFIX WITH NUMBER SHOWN ON SHEET 2 OF 6 OF ASSEMBLY.

NOTES UNLESS OTHERWISE SPECIFIED

| QTY REQD | PART OR IDENTIFYING NO | NOMENCLATURE OR DESCRIPTION | MFR CODE | CIRCUIT REF. | ITEM NO. |
|---|---|---|---|---|---|

38-4 | 38-4 | 1 | 1
NEXT ASSY | FINAL ASSY | APPLICATION

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES ON
DECIMALS ± .010 ANGLES ± 0° 30'
FRACTIONS ± 1/32
SURFACE ROUGHNESS PER M-L-STD-10 ✓
DO NOT SCALE THIS DRAWING
RELEASE DATE

MATERIAL

FIN. SH

NON-LINEAR SYSTEMS, INC
DEL MAR CALIFORNIA

ASSY, AMP & LOGIC
SCHEMATIC -
SERIES X-3

CODE IDENT NO 03626 | SIZE D | 38-113

SCALE | WEIGHT | SHEET 2 of 2

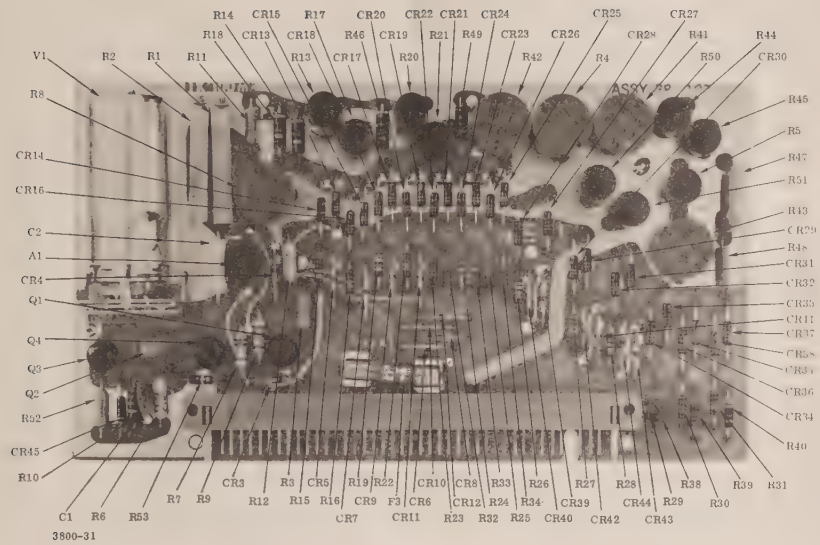


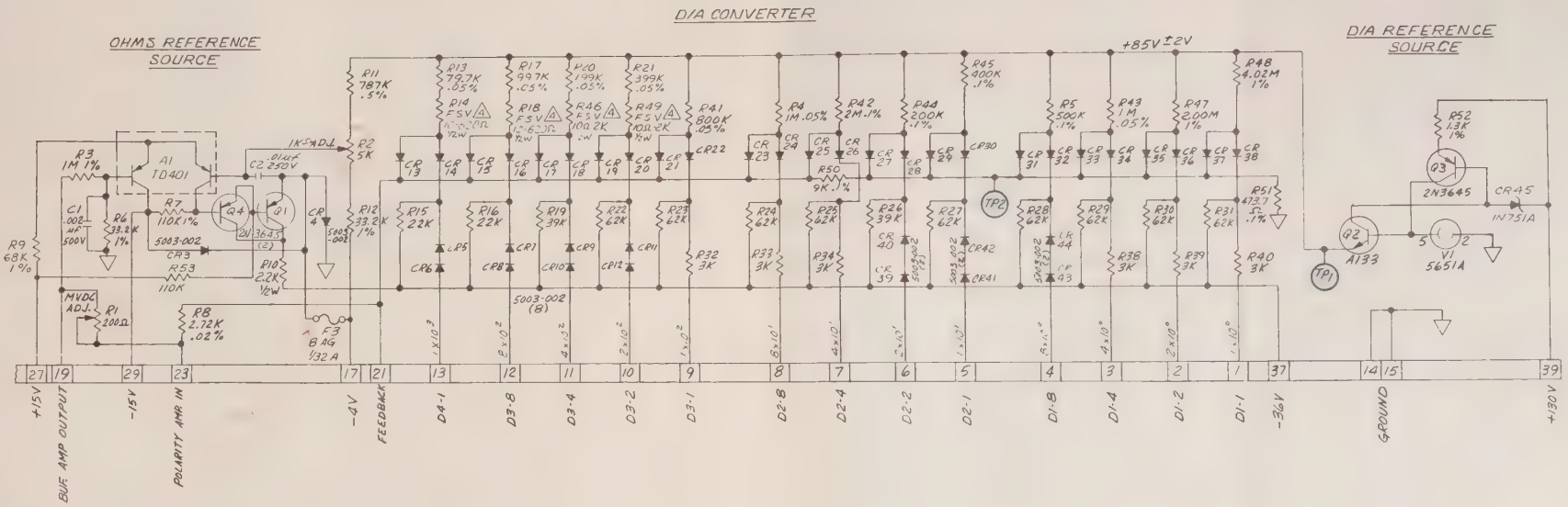

Figure 5-7. D/A Converter and Reference Assembly

D/A Converter and Reference Assembly, P/N 38-107

| CIRCUIT REFERENCE | PART NO. | DESCRIPTION | QTY PER ASSY. | MANUFACTURER'S CODE |
|---|---|---|---|---|
| A1 | TD401 | AMPLIFIER | 1 | 80183 |
| C1 | 5002-010 | CAPACITOR, 0.002μF, 500V | 1 | 03626 |
| C2 | C291AB/A10K | CAPACITOR, 0.01μF, 250V | 1 | 73445 |
| CR3 thru CR12 & CR39 thru CR44 | 5003-002 | DIODE | 16 | 03626 |
| CR13 thru CR38 | 5003-007/S325* | DIODE | 26 | 99142 |
| CR45 | IN751A | DIODE, ZENER | 1 | 81483 |
| F3 | 361.031 | FUSE, 8AG, 1/32A | 1 | 75915 |
| Q1, Q3 & Q4 | 2N3645 | TRANSISTOR | 3 | 07263 |
| Q2 | A133/2N720A*/ 2N1893* | TRANSISTOR | 1 | |
| R1 | 78PR 200Ω | POTENTIOMETER 200Ω | 1 | 71590 |
| R2 | 78PR -5K | POTENTIOMETER, 5K | 1 | 71590 |
| R3 | RN60D1004F | RESISTOR, 1M, 0.1% | 1 | 01121 |
| R4 & R43 | PW2016C | RESISTOR, 1M, 0.05% | 2 | 03626 |
| R5 | PW2016C | RESISTOR, 500K, 0.1% | 1 | 03626 |
| R6 & R12 | RN60C3322F | RESISTOR, 33.2K, 0.1% | 2 | 01121 |
| R7 | RN60D1103/GP42* | RESISTOR, 110K, 0.1% | 1 | 01121 |
| R8 | PW2016C | RESISTOR, 0.02% | 1 | 03626 |
| R9 | RN60D6812F/ GP42* | RESISTOR, 68.1K/68K*, 0.1% | 1 | 01121 |
| R10 | RC20GF222J | RESISTOR, 2.2K, 1/2W, 5% | 1 | 01121 |
| R11 | RN60C7873C | RESISTOR, 787K, 0.5% | 1 | 01121 |
| R13 R17 | PW2016CD | RESISTOR, DUAL 79.7K, 0.05% 99.7K, 0.05% | 1 | 03626 |
| R14 & R18 | RC20GF | RESISTOR, 10-620Ω*, 1/2W (Factory Selected Value) | 2 | 01121 |
| R15 & R16 | RC07GF223J | RESISTOR, 22K, 1/4W, 5% | 2 | 01121 |
| R19 & R26 | RC07GF393J | RESISTOR, 39K, 1/4W, 5% | 2 | 01121 |
| R20 R21 | PW2016CD | RESISTOR, DUAL 199K, 0.05% 399K, 0.05% | 1 | 03626 |
| R22 thru R25 & R27 thru R31 | RC07GF623J | RESISTOR, 62K, 1/4W, 5% | 9 | 01121 |
| R32 thru R34 & R38 thru R40 | RC07GF302J | RESISTOR, 3K, 1/4W, 5% | 6 | 01121 |
| R41 | PW2016C | RESISTOR, 800K, 0.05% | 1 | 03626 |
| R42 | PW2016C | RESISTOR, 2 Meg, 0.1% | 1 | 03626 |
| R44 R45 | PW2016CD | RESISTOR, DUAL 200K, 0.1% 400K, 0.1% | 1 | 03626 |
| R46 & R49 | RC20GF | RESISTOR, 10Ω-2K, 1/2W (Factory Selected Value) | 2 | 01121 |
| R50 | PW1224C | RESISTOR, 9K, 0.1% | 1 | 03626 |
| R51 | PW1224C | RESISTOR, 473.7Ω, 0.1% | 1 | 03626 |
| R52 | RN60D1301F/ GP 1/2* | RESISTOR, 1.3K, 1% | 1 | 01121 |
| R53 | RC07GF114J | RESISTOR, 110K, 1/4W, 5% | 1 | 01121 |
| V1 | 5651A | TUBE, REGULATOR | 1 | 03607 |

*Alternate

| REVISIONS | | | | | |
|---|---|---|---|---|---|
| ZONE | LTR | EFFECT | DESCRIPTION | DATE | APPROVED |
| B&C -18 | A | ALL | INCORP E.O.1 THRU 0" R7 WAS 20K 1% R9 WAS 13K 1%. 8 27-65 JMH. | | |




| QTY REQD | PART OR IDENTIFYING NO. | NOMENCLATURE OR DESCRIPTION | MFR CODE | CIRCUIT REF. | ITEM NO. |
|---|---|---|---|---|---|

PARTS LIST

⚠ VALUE TO BE DETERMINED DURING CHECKOUT PROCEDURE, RESISTOR SELECTED MAY BE ONE OF THE STD. EIA/MIL VALUES WITHIN THE RANGE INDICATED.

3. ALL DIODES ARE 5003-007 Y/ALTERNATE 5325.

2. ALL RESISTORS ARE ¼W 5% CARBON.

1. REFERENCE DESIGNATIONS ARE ABBREVIATED; PREFIX WITH ASSEMBLY DESIGNATION SHOWN ON SHEET 2 OF THIS ASSEMBLY

NOTES: UNLESS OTHERWISE SPECIFIED

| UNLESS OTHERWISE SPECIFIED | CONTR. NO. | |
|---|---|---|
| DIMENSIONS ARE IN INCHES TOLERANCES ON DECIMALS ± .010 ANGLES ± 0° 30' FRACTIONS ± 1/32 | DRAWN | WEINBERG 2-15-68 |
| | CHECK | 16-28-64 |
| | APPR | 2-21-68 |
| | RELEASE DATE | 2-16-68 |
| MATERIAL | | |

| NEXT ASSY. | FINAL ASSY. | NEXT ASSY. | F.N.A. ASSY. |
|---|---|---|---|
| 38-4 | 38-4 | 1 | 1 |
| APPLICATION | | QTY. | |

NON-LINEAR SYSTEMS, INC.
DEL MAR, CALIFORNIA

ASSY, D/A CONVERTER & REF.
-SCHEMATIC-
SERIES X3

| SIZE | CODE IDENT NO | |
|---|---|---|
| D | 03626 | 38-107 |
| SCALE | WEIGHT | SHEET 2 OF 2 |

38-107 SH 2

5-11/5-12

# CHAPTER VI

## RECOMMENDED SPARE PARTS LIST

| Part No. | Description | Qty |
|---|---|---|
| 38-98 | Attenuator Assembly | 1 |
| 38-107 | D/A Converter and Reference Assembly | 1 |
| 38-113 | Amplifier and Logic Assembly | 1 |
| 38-115 | R/O and Counter Assembly | 1 |
| 38-64 | Amplifier | 1 |
| 38-141 | Amplifier and Oven Assembly | 1 |
| IN3024B | Diode | 1 |
| IN3047B | Diode | 1 |
| IN3866 | Diode | 1 |
| IN4003 | Diode | 1 |
| IN4005 | Diode | 1 |
| IN458 | Diode | 1 |
| 5003-002 | Diode | 5 |
| 5003-007 | Diode | 2 |
| SN7400N | Dip, Quad Input Gate | 1 |
| SN7441AN | Dip, Decode Driver | 1 |
| SN7490N | Dip, Decade Counter | 1 |
| 313.375 | Fuse, 3A6, 3/8 A, Slo-Blo | 6 |
| 3131001 | Fuse, 3A6, 1A, Slo-Blo | 6 |
| 361.031 | Fuse, 8A6, 1/32 A, Slo-Blo | 6 |
| A133 | Transistor | 1 |
| MPS6519 | Transistor | 1 |
| 2N1302 | Transistor | 1 |
| 2N3645 | Transistor | 1 |
| 2N3702 | Transistor | 1 |
| 2N3704 | Transistor | 1 |
| 2N3711 | Transistor | 3 |
| 2N3740 | Transistor | 1 |
| 2N4418 | Transistor | 1 |
| 40346 | Transistor | 1 |
| B5440 | Tube, Indicator (0 thru 9 & Decimal) | 1 |
| B5441 | Tube, Indicator (0 and 1) | 1 |
| B5448 | Tube, Indicator (Polarity & $\mathfrak{P}$) | 1 |

# APPENDIX

## SHIPPING INSTRUCTIONS

Depending upon location, the choice of carrier will vary. Never ship an instrument to us without having received shipping instructions. If requested, an estimate of charges can be made before work begins.

Be certain to pack the instrument carefully; while an outer and inner box, separated by two or three inches of excelsior is desirable, the instrument can be placed into a single container provided it is so packed that it will not shift about. As with the double box method, use two or three inches of shock-absorbent packing materials. The instrument itself should be first wrapped in heavy paper so as to keep excelsior or other particles from entering the instrument's louvers. If the original shipping container is in good condition, it may be used.

## CLAIM FOR DAMAGE IN SHIPMENT

The instrument should be tested as soon as it is received. If it does not operate or is damaged, a claim should be made with the carrier. The claim agent should receive a full report of damage, and this report sent to Non-Linear Systems, Inc. After receiving such a report we will advise you of the disposition of the instrument and arrange for its repair or replacement. Be certain to include model and serial number when corresponding.

non linear
systems, inc.

DEL MAR, CALIFORNIA

www.manualsplus.com
1022508